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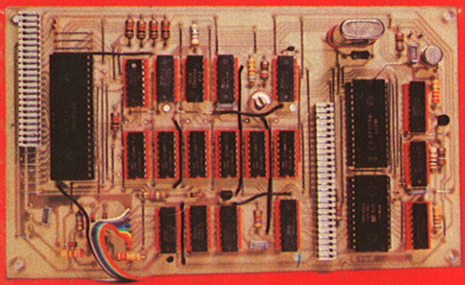

elekterminal

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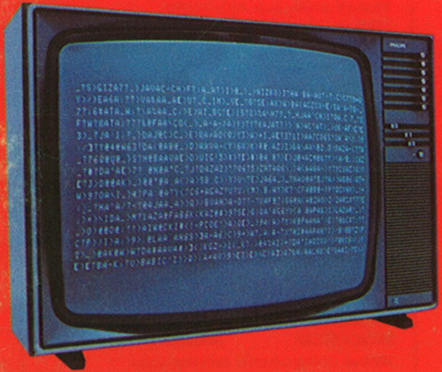

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2N718	0.30
2N718A	0.54
2N720A	0.85
2N722	0.45
2N727	0.50
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ME4002	0.16
ME4003	0.16
ME4101	0.11
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ME4103	0.11
ME4104	0.11
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MJ2955	1.35
MJE340	0.62
MJE370	0.62
MJE371	0.86
MJE520	0.50
MJE521	0.70
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MPF3055	1.05
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MPF103	0.44
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MPS105	0.44
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TIP30C	0.70
TIP31A	0.54
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TIP41C	0.97
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TIP2955	0.70
TIP3055	0.59
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TIS43	0.47
TIS90	0.22
TIS91	0.27
TIS92	0.33
TIS93	0.36
ZTX300	0.17
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LM388N	1.00
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LM70914	0.49
LM710	0.67
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LM711CN	0.72
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LM723C14	0.45
LM741C	0.70
LM741C8	0.30
LM741C14	0.30
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LM74814	0.90
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LM1458N	0.45
LM1496N	0.97
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LM1889N	4.90
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LM3302N	0.55
LM3401N	0.55
LM3900N	0.68
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LM3909N	0.78
LM3911N	1.10
LM7805K	1.75
LM7812K	1.75
LM324	0.75
LM7815K	1.75
LM7824K	1.75
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NE556	0.85
NE558N	1.98
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NE567	1.90
NE571N	4.95
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SAJ110	2.10
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SN76003N	2.38
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TAA522	2.10
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TAA560	2.10
TAA570	2.20
TAA370A	5.45
TAA630	2.40
TAA960	3.90
TAA970	4.20
TAA611B	2.50
TAA621	2.50
TAA661A	1.65
TAA661B	1.45
TAA700	4.50
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TAA930B	1.45
TAD100	2.00
TBA120	0.80
TBA500	2.24
TBA500Q	2.34
TBA510	2.35
TBA510Q	2.48
TBA520	2.60
TBA520Q	2.70
TBA530	2.35
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TBA550	3.60
TBA550Q	3.80
TBA5600Q	3.00
TBA570	2.10
TBA570Q	2.20
TBA700Q	2.20
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TBA750Q	2.45
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TCA750	3.00
TCA760	2.00
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TCA440	1.65
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TDA1024	1.24
TDA1034	4.75
TDA2020AD	4.50
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TL083CN	1.40
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4007	0.22	4020B	1.15	4041B	0.85	4055	1.65	4075B	0.24	4097	4.65
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4009	0.58	4022B	1.00	4043	1.05	4059	6.00	4077	0.70	4510B	1.20
4010	0.58	4023B	0.22	4044	1.00	4060B	1.15	4078	0.27	4511	1.75
4011B	0.22	4024B	0.76	4045	1.76	4063	1.35	4081B	0.24	4516	2.10
4012	0.22	4025B	0.22	4046B	1.50	4066B	0.75	4082	0.27	4518B	1.20
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74LS04N	0.29
74LS08N	0.26
74LS10N	0.26
74LS12N	0.26
74LS13N	0.58
74LS14N	1.43
74LS20N	0.26
74LS26N	0.39
74LS27N	0.50
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74LS38N	0.32
74LS40N	0.29
74LS42N	1.07
74LS47N	1.09
74LS48N	1.09
74LS49N	1.09
74LS51N	0.26
74LS54N	0.26
74LS73N	0.42
74LS74N	0.42
74LS75N	0.58
74LS76N	0.42
74LS78N	0.42
74LS83AN	1.20
74LS85N	1.10
74LS86N	0.44
74LS90N	1.10
74LS91N	1.20
74LS92N	0.86
74LS93N	1.10
74LS95AN	1.10
74LS96N	1.35
74LS107N	0.42
74LS109N	0.42
74LS122N	0.80
74LS123N	0.83
74LS124N	2.70
74LS125N	0.50
74LS126N	0.50
74LS132N	0.85
74LS136N	0.44
74LS138N	0.65
74LS139N	0.65
74LS145N	1.30
74LS151N	1.07
74LS153N	0.58
74LS154N	1.45
74LS155N	1.20
74LS156N	1.20
74LS157N	0.60
74LS158N	0.65
74LS160N	1.43
74LS161N	0.85
74LS162N	1.43
74LS163N	0.85
74LS164N	1.43
74LS168N	2.43
74LS169N	2.43
74LS174N	1.33
74LS175N	1.26
74LS181N	3.95
74LS189N	3.74
74LS190N	1.00
74LS191N	1.00
74LS192N	1.98
74LS193N	1.98
74LS196N	1.28
74C00N	0.24
74C02N	0.24
74C04N	0.24
74C08N	0.24
74C10N	0.24
74C14N	1.41
74C20N	0.24
74C30N	0.24
74C32N	0.24
74C42N	0.92
74C48N	1.38
74C73N	0.54
74C74N	0.56
74C76N	0.54
74C83N	1.30
74C85N	1.30
74C86N	0.64
74C89N	4.39
74C90N	0.85
74C93N	0.85
74C95N	1.04
74C107N	1.22
74C150N	4.14
74C151N	2.47
74C154N	3.68
74C157N	2.21
74C160N	1.11
74C161N	1.11
74C162N	1.11
74C163N	1.11
74C164N	1.04
74C165N	1.04
74C173N	0.90
74C174N	0.90
74C175N	0.90
74C192N	1.11
74C193N	1.11
74C195N	1.04
7400N	0.17
7401N	0.17
7402N	0.17
7403N	0.17
7404N	0.17
7405N	0.22
7406N	0.56
7407N	0.55
7408N	0.22
7409N	0.22
7410N	0.20
7411N	0.26
7412N	0.20
7413N	0.36
7414N	0.80
7416N	0.36
7417N	0.36
7420N	0.22
7423N	0.32
7425N	0.32
7427N	0.32
7430N	0.22
7432N	0.30
7437N	0.35
7438N	0.32
7440N	0.20
7441AN	0.84
7442N	0.76
7445N	1.40
7446N	0.90
7447N	0.80
7448N	0.80
7450N	0.22
7451N	0.22
7453N	0.22
7454N	0.22
7460N	0.22
7470N	0.46
7472N	0.30
7473N	0.44
7474N	0.32
7475N	0.80
7476N	0.45
7480N	0.60
7481N	1.00
7482N	0.90
7483N	1.05
7484N	1.20
7485N	1.36
7486N	0.36
7489N	2.45
7490AN	0.45
7491AN	0.85
7492N	0.45
7493N	0.45
7494N	0.90
7495N	0.76
7496N	0.70
7497N	1.95
74100N	1.40
74107N	0.35
74118N	0.95
74119N	1.40
74121N	0.28
74122N	0.55
74123N	0.55
74125N	0.45
74141N	0.86
74148N	1.35
74145N	0.86
74148N	1.35
74150N	1.20
74151N	0.76
74153N	0.76
74154N	1.20
74155N	0.70
74157N	0.78
74160AN	1.10
74161AN	1.10
74162AN	1.10
74163AN	1.10
74164N	1.36
74165N	1.36
74167N	2.50
74174N	1.60
74175N	1.00
74176N	0.90
74177N	0.90
74180N	1.00
74181N	2.00
74182N	0.80
74184N	1.50
74185AN	1.50
74188AN	3.25
74189N	2.60
74190N	1.40
74191N	1.20
74192N	1.20
74193N	1.20
74196N	1.20
74197N	1.00
74198N	2.00
74199N	2.00

Please see special offer- Reply paid card in this issue

NEW LOW PRICES

LEDS + OPTO BY SIEMENS

Displays 7 seg			LEDS	Red	Gr	Yell
Com anode or cath			Small 3mm	.18	.19	.19
Red			Large 5mm	.20	.20	.20
8mm	HT	£1.50	Extra			
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48 page catalogue – new enlarged micro section – largest range of quality components from franchised suppliers available in UK. All VAT inclusive prices. Over 8,000 line items plus lots more. 50p post paid or 40p to callers at any of our four branches.

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Low profile IC skts

8 pin	15p	22 pin	30p
14 pin	16p	24 pin	35p
16 pin	18p	28 pin	45p
18 pin	27p	40 pin	55p

FULL RANGE OF

Capacitors
Resistors
Plugs/skts
Meters
Clocks

Diodes
Cables
Cases
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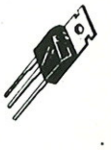
TRIACS plastic pack 400v TO220
Texas

4 amp	72p	16 amp	93p
6 amp	77p	20 amp	£1.87
8 amp	82p	25 amp	£2.20
12 amp	93p		

THYRISTORS plastic power

4 amps	8 amps	12 amps
100v o 38	100v o 47	100v o 63
200v o 44	200v o 54	200v o 70
400v o 54	400v o 68	400v o 90

Branded Texas quality product



CONVERT TV SET TO VDU

The new CRT control chip from Thomson CSF SFF96364. Convert your TV set into an electronic VDU – 16 lines x 64 characters – requires RAM character generator and little else for a basic VDU. Available as chip or full display card. Full cursor control 5 volts TTL compatible, line erase, full card includes UART, Modem, Char, gen etc. Comp video out from encoded keybd. in

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CHIP £17·20
FULL CARD
£151

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Intersil

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T106 kit
LCD display. Batt operated
Contains all components reqd for construction plus PCB. Auto vero extremely versatile and accurate easy assembly kit.

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TEXAS **ANTEX**
MULLARD **ELECTROLUBE**
SIEMENS **SIFAM**
SESCOSEM **ARROW HART**

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48 PAGES FOR 1979

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Electronic Components Division

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Quantity and trade enquiries welcomed for all components.
Quantity and trade enquires welcomed for all components.

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IC's

PRICE REDUCTIONS

CA3080	OTA	TO5	95
CA3084			300
CA3086	transistor array	14 dil	75
CA3090AQ	decoder	14 dil	575
CA3130T	opamp	TO5	120
CA3140T	FET opamp	TO5	120
ICM7038A	clock time base	8 dil	495
L129	5 V regulator	TO220	125
L130	12 V regulator	TO220	125
L131	15 V regulator	TO220	125
LF356	Bi Fet opamp	TO5	150
LD110CJ	digital DVM processor	16 dil	825
LD111CJ	analogue DVM		960
LM301AN	opamp	8 dil	70
LM308N	opamp	8 dil	130
LM311H	voltage comparator	TO5	150
LM317K	adjust reg.	TO3	400
LM311H	voltage comparator	TO5	255
LM318N	opamp	14 dil	310
LM324N	quad opamp	14 dil	98
LM325H	15 V regulator	TO5	360
LM326H	12 V regulator	TO5	360
LM327H	+ 5 − 12 V regulator	TO5	360
LM380N	audio amp	14 dil	140•
LM381N	dual audio pre amp	14 dil	220•
LM391	high power audio amp	16 dil	180•
LM555N	timer	8 dil	35
LM556N	dual timer	14 dil	85
LM556CN	vco	14 dil	170
LM567N	Pll tone decoder	8 dil	270
LM703LH	rf amp	TO5	100
LM709CN	opamp	8 dil	50
LM723CH	voltage regulator	TO5	75
LM723CN	voltage reg.	14 dil	85
LM741CN	opamp	8 dil	30
LM78L05	Voltage Reg	T092	38
LM78L05	Voltage Reg	T0220	95
LM78L012	Voltage Reg	T092	38
LM78L012	Voltage Reg	T0220	95
LM78L015	Voltage Reg	T092	38
LM78L015	Voltage Reg	T0220	95
LM1812N	ultra sonic transceiver	14 dil	720
LM1889	VHF Mod	18 dil	560
LM3900N	quad norton amp	14 dil	75
LM3909N	led flasher	8 dil	90
LM3911H	temp. transducer	TO5	180
M252	rhythm generator	16 dil	1175•
MC1310P	decoder	14 dil	220•
MC1312P	matrix SQ	14 dil	250•
MC1314P	vca SQ	16 dil	400•
MC1315P	logic control SQ	16 dil	600•
MC1458CP1	dual opamp	14 dil	90
MC1468L	dual regulator	14 dil	420
MC14440L	watch	40 dil	1393
MC1440Z	watch	flat pack	1600
MC14543CP	LCD driver	16 dil	147
MC14553P	3 digit counter	16 dil	396
MC14566P	time base	16 dil	132
MM2112	1K ram	16 dil	295
MM5204Q	EPROM	16 dil	POA
MM5314N	clock MPX 7 seg	24 dil	450
MM5316N	clokc non MPZ 7 seg	40 dil	550
MM5318N	clock BCD + address		740
MM5817	Noise generator		450
MM5841N	TV display driver	28 dil	1350•
RG4194TC	dual regulator	TO66	895
RC4151DN	V to F convertor	8 dil	750
SBV566	hall switch		120
SCMP1	ISP8A500D	40 dil	1250
SCMP2	ISP8A600N	40 dil	1000
SL440	Triac phase control	14 dil	450
SN76013N	audio	16 dil	180•
SN76131N	audio	14 dil	195•
SO41P	mixer	14 dil	195
SO42P	mixer	14 dil	195
STK025	Audio power IC		725•
STK032	Audio power IC		920
TAA550A	regulator	TO18	55
TAA861	opamp	TO5	155
TBA120	mixer	14 dil	95
TBA120T	IF	14 dil	95
TBA231	dual audio pre amp	14 dil	200•
TBA625A	5 V 100 mA regulator	TO5	110
TBA625B	12 V 100 mA regulator	TO5	110
TBA625C	15 V 100 mA regulator	TO5	110
TBA800SW	audio amp	16 quil	205•
TBA810S	audio amp		270•
TCA220	Triple opamp	16 dil	450
TCA280A			235
TCA740	DC tone	16 dil	530•
TDA1022	analogue shift register	16 dil	935
TDA1024	Triac Control 8 pin DIL		1.40
TDA2002	5 W 12 V audio amp		475
TDA2020	20W audio amp	14 quil	550•
U112B	triac control	14 dil	375
U113B	remote switch	4 dil	150
UAA170	led driver	16 dil	220
UAA180	led driver	18 dil	230
UA78G	regulator	TO220	235
UA79G	regulator	TO3	250
XR2206CP	function generator	16 dil	890
XR2207CP	VCO	14 dil	490
XR4212	Quad op amp	14 dil	250

LOW COST CMOS

4000	.16	4044	.93	4440	13,93
4001	.16	4046	1.23	4450	3.22
4002	.16	4049	.39	4450	3.22
4006	1.00	4050	.39	4490	7.83
4007	.16	4051	.39	4501	.16
4008	.91	4052	.85	4502	.81
4011	.16	4053	.85	4503	.67
4012	.16	4066	.85	4507	.34
4013	.39	4068	.57	4508	2.27
4014	.94	4069	.16	4510	1.14
4015	.94	4070	.16	4511	1.42
4016	.93	4071	.16	4512	1.05
4017	.94	4072	.16	4516	1.14
4018	.94	4073	.16	4517	3.37
4020	1.04	4075	.16	4521	1.78
4021	.94	4076	1.21	4522	1.31
4022	.85	4077	.16	4526	1.11
4023	.16	4078	.16	4527	1.49
4024	.69	4081	.16	4528	.98
4025	.16	4082	.16	4529	1.08
4027	.46	4093	.57	4530	.64
4028	.84	4160	1.08	4536	3.30
4032	.94	4161	1.08	4541	1.27
4035	1.02	4162	1.08	4543	1.47
4038	.99	4163	1.08	4553	3.96
4040	1.03	4174	.98	4557	3.81
4042	.69	4175	.90	4566	1.32
4043	.93	4194	1.07	4583	.70
				4584	.56

EXPERIMENTING WITH SC/MP

BUILD YOUR OWN MICROPROCESSOR DEVELOPMENT SYSTEM

The current Elektor series leads to the construction of a hexadecimal seven segment microcomputer with a cassette interface. Further development is planned, to produce a private computor system with visual display unit, cassette based programmes and an extended memory capacity.

To enable you to reduce your costs we are preparing a kit order list for each part of the series to enable you to order just those parts you need and not to duplicate components you already have.

Please send SAE for lists or phone Kettering 520910 for further details about the series.

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BC107/8/9	85p/10
BC547/8/9	75p/10
BC557/8/9	75p/10
BC516/517	2.80/10
BC212/3/4	75p/10
IN4001/2/3	48p/10
1N4004/5	55p/10
1N4007	70p/10
1N4148	2.20/100
Red LED 0.2	95p/10
Red LED .125	95p/10
Yellow/Green 0.2	1.20/10
Yellow/Green .125	1.00/10
DL707	3.50/4
LM741 op amp 8 pin DIL	1.80/10
LM555 timer	2.60/10
LM324	7.00/10
8 pin DIL socket	1.00/10
14 pin DIL socket	1.10/10
16 pin DIL socket	1.20/10

74 SERIES TTL

PRICE REDUCTIONS

7400	12	7416	28	7439	30	7472	26	7493	44	74128	62	74156	70	74177	85
7401	12	7417	28	7440	18	7473	30	7494	80	74132	60	74157	70	74180	85
7402	14	7420	15	7441	52	7474	28	7495	60	74136	75	74160	90	74181	220
7403	14	7421	40	7442	62	7475	45	7496	65	74137	80	74161	90	74182	80
7404	14	7422	20	7443	120	7476	32	74100	120	74141	70	74162	90	74185	150
7405	14	7423	25	7444	120	7480	48	74104	52	74142	290	74163	90	74189	320
7406	30	7424	30	7445	75	7481	115	74105	52	74143	290	74164	100	74190	120
7407	32	7425	26	7446	120	7482	85	74107	35	74144	290	74165	100	74191	120
7408	18	7426	26	7447	65	7483	75	74109	48	74145	65	74166	100	74192	95
7409	18	7427	26	7448	65	7484	120	74110	50	74147	150	74167	325	74193	98
7410	15	7428	40	7450	15	7485	80	74118	90	74148	140	74170	160	74194	95
7411	24	7430	15	7451	15	7486	30	74121	38	74150	100	74172	600	74195	75
7412	26	7432	26	7453	15	7489	220	74122	65	74151	62	74173	130	74196	95
7413	30	7433	47	7454	15	7490	38	74123	58	74153	55	74174	90	74197	92
7414	70	7437	26	7460	15	7491	76	74125	46	74154	80	74175	72	74198	150
7415	34	7438	26	7470	30	7492	44	74126	46	74155	70	74176	85	74199	160

HARDWARE & EQUIPMENT

Edge connectors 64 way (SC/MP) (pair) 7.00
Edge connectors 31 way (format) (pair) 3.00
Edge connectors 31 way (test pattern gen) (pair) 1.50

SWITCHES

ROTARY
1 pole 12 way 54
2 pole 6 way 54
3 pole 4 way 54
4 pole 3 way 54

SLIDE
2 pole 2 way 18

MINIATURE TOGGLE
1 pole 1 way 65
1 pole 2 way 65
2 pole 1 way 65
2 pole 2 way 75
2 pole 2 way c/off 75
2 pole 2 way biased 80
2 pole 2 way locking 80
2 pole 2 way c/off 130

MINIATURE PUSH
1 pole 1 way non latching 15
1 pole 1 way latching 55
1 pole 2 way latching 60
2 pole 2 way latching 90
4 pole 1 way non latching 45

TRANSISTOR SOCKET; TO18; TO5 10 each

SILVER PLATED COPPER WIRE
18 swg 60/mtr
22 swg 50/mtr
24 swg 45/mtr

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8 pin 12
14 pin 14
16 pin 16
24 pin 45
40 pin 65

LOUDSPEAKERS
64 ohm 2.5 ins 75•
8 ohm 2.5 ins 60•

VEROBOARD 0.1 inch
2.5 x 3.75 inch 42
2.5 x 5 inch 50
3.75 x 5 inch 56
V-Q board 01-0044C 91

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Spare elements for C2 145 for CCN/R 190
For X25 160

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50p

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7.5 mm radial leads – direct fit for many EPS boards.
Tolerance: + 10% up to 8n2 + 5% 10n and above
max. wkg. voltage: 250 V DC up to 47n 100 V DC 56n and above.

		individual price
1000 pF	1n0	5•
1500 pF	1n5	5•
2200 pF	2n2	5•
3300 pF	3n3	5•
4700 pF	4n7	5•
6800 pF	6n8	5•
8200 pF	8n2	6•
0.01 uF	10n	6•
0.012 uF	12n	6•
0.015 uF	15n	6•
0.018 uF	18n	6•
0.022 uF	22n	6•
0.027 uF	27n	6•
0.033 uF	33n	6•
0.039 uF	39n	6•
0.047 uF	47n	7•
0.056 uF	56n	7•
0.068 uF	68n	7•
0.082 uF	82n	7•
0.1 uF	100n	7•
0.12 uF	120n	8•
0.15 uF	150n	8•
0.18 uF	180n	10•
0.22 uF	220n	10•
0.27 uF	270n	12•
0.33 uF	330n	14•
0.39 uF	390n	16•
0.47 uF	470n	16•
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0.68 uF	680n	20•
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Close tolerance high stability sub-miniature plate capacitors. 63 V dc. E6 series values.

1 pF to 8.2 pF 4•
10 pF to 82 pF 5•
100 pF to 820 pF 7•

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uF	V 6.3	10	16	25	35	63
0.47;1.0;1.5						8•
2.2						8•
3.3					8•	9•
4.7				8•	9•	9•
10			8•	8•	9•	12•
15		8•	9•	9•	11•	15•
22	8•	8•	8•	9•	11•	15•
33	8•	9•	9•	11•	12•	16•
47	9•	9•	10•	12•	15•	22•
100	10•	12•	12•	16•	20•	36•
220	12•	14•	16•	21•	27•	50•
330	15•	17•	18•	24•	33•	70•
470	16•	19•	21•	31•	39•	90•
1000	21•	24•	33•	46•	72•	110•
2200	33•	40•	52•	79•	122•	150•
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32.768	kHz	KDT-3	3.20
32.768	kHz	MTQ 32-12	6.00
1.0	MHz	HC 33/U	4.50
2	MHz	HC 33/U	4.50
3.2768	MHz	HC 33/U	4.50
4.19304	MHz	HC 33/U	4.50
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10.25	MHz	HC 18/U	3.00
27	MHz	HC 25/U	2.15
39	MHz	HC 25/U	2.15

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SFE 6.0 MA ... 60
SFE 10.7 70
CFT 455B 70
SFD 455B 70
CDA 10.7 MA 150
TV Crystal 4.433619 MHz 2.00

Fixed inducers for PC mounting values E12 0.1 uH to 100 mH., Ring or write for details.

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BA127	11	BD140	45•	TIP31A	40•
BB104	60•	BD240	70	TIP41A	60
BB105	37•	BD241A	70	TIP42A	70
BB106	55•	BD242	75	TIS43	35
BB109	49•	BF194	09•	IN4001	05
BC107	10	BF195	09•	1N4002	05
BC108	10	BF199	15	1N4003	06
BC109	10	BF200	30	1N4004	06
BC140	42	BF225	20	1N4005	07
BC160	35	BF244	30	1N4006	07
BC177	18	BF245	28	1N4007	07
BC182L	10•	BF245c	30	1N4148	05
BC184L	10•	BF254	18	2N2219	25
BC212L	10•	BF494	45	2N3054	50
BC214L	10•	BF495	45	2N3055	50
BC516	30	BFX29	25	2N3702	09
BC517	35	BFY50	19	2N3703	09
BC547	10•	BFY51	19	2N3704	09
BC547b	12•	BFY52	19	2N3705	09
BC548	10•	BFY90	85	2N3819	18
BC549	10•	BRY39	35	2N5777	65
BC549b	12•	BRY56	45	40603	80
BC549c	13•	BY127	10	Zener Diodes 1W	
BC557	12•	BY164	70	3.3v to	
BC557b	15•	BY187	1.35	Zener Diodes	
BC558	12•	E100	40	400mW 2.7v to 47v	
BC559	12•	E300	45	E12 Series	12•
BC559b	15•	E310	60	Bridge rectifiers	
BC559c	16•	E420	1.60	for Elektor projects	
BCY70	19	E430	1.45	B 40C800W	40
BCY71	20	MJE340	80	B 40C5000	60
BD131	45•	MJE341	65	B250C1000	70
BD132	45•	MJE2955	1.40	B250C22001	50
BD138	53•	MJE3055	1.20		

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Where our sister company, HB computers will be demonstrating the PET 2001, now in stock.

MICROPROCESSORS & PERIFI

Micro's and Memories

Send SAE for lists of development kits etc.

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MC1488 RS 232 Interface	1.40
MC1489 RS 232 Interface	1.40
MM1702A EPROM 256 x 8	4.98
MM2102AN RAM 1k x 1	1.50
MM2107B	4.50
MM2112 RAM 256 x 4	2.95
MM2708 EPROM 1k x 8	10.50
271AJ EPROM 2k x 8	21.00
MM5204 (Blank) EPROM 512 x 8	10.50
SC/MP 1SP8A 500D MPU	12.50
SC/MP 1SP 8A 600D MPU	10.50
COSMAC vid computer on a card with built in PSU sound effects gen ans TV interface. Complete with HEX keypad, monitor in ROM + 2048 byte of RAM	£230

OPTOELECTRONICS

PRICE REDUCTIONS

Display	drive	decimal point	size	mounting	digits	price
DL704	CC	RDP	0.3"	14 dil	single	1.20
DL707	CA	LDP	0.3"	14 dil	single	1.20
DL727	CA	RDP	0.5"	18 dil	dual	1.95
DL728	CC	RDP	0.5"	18 dil	dual	2.20
DL747	CA	LDP	0.63"	18 dil	single	2.20
DL750	CC	LDP	0.63"	18 dil	single	2.20
FND500					single	1.65
HP7730	CA	LDP	0.3"	14 dil	single	1.80
HP7732	CA	LDP	0.3"	14 dil	1	2.30
HP7750						1.80

BPW 34	photo diode	2.60
IL 74	opto isolator	1.10
IRL 60	infra red led	.70
LD 241	infra red transmitter	2.40
2N5777	photo darlington	.65
ORP 12	light dependent resistor	.80
Wire ended neon		.20
LED red 0.2"		.15
LED red 0.125"		.12
LED green; yellow; clear 0.2"		.22
LED green, yellow; 0.125"		.22

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For technical queries, please enclose a stamped, addressed envelope or a self-addressed envelope plus an IRC.

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ABC
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decoder

What is a TUN?
What is 10 n?
What is the EPS service?
What is the TQ service?
What is a missing link?

Semiconductor types
Very often, a large number of equivalent semiconductors exist with different type numbers. For this reason, 'abbreviated' type numbers are used in Elektor wherever possible:

- '741' stand for µA741, LM741, MC641, MIC741, RM741, SN72741, etc.
- 'TUP' or 'TUN' (Transistor, Universal, PNP or NPN respectively) stand for any low frequency silicon transistor that meets the following specifications:

U_{CEO}, max	20V
I_C, max	100 mA
h_{fe}, min	100
P_{tot}, max	100 mW
f_T, min	100 MHz

Some **'TUN'**s are: BC107, BC108 and BC109 families; 2N3856A, 2N3859, 2N3860, 2N3904, 2N3947, 2N4124. Some **'TUP'**s are: BC177 and BC178 families; BC179 family with the possible exeption of BC159 and BC179; 2N2412, 2N3251, 2N3906, 2N4126, 2N4291.

- 'DUS' or 'DUG' (Diode Universal, Silicon or Germanium respectively) stands for any diode that meets the following specifications:

	DUS	DUG
U_R, max	25V	20V
I_F, max	100mA	35mA
I_R, max	1µA	100 µA
P_{tot}, max	250mW	250mW
C_D, max	5pF	10pF

Some **'DUS'**s are: BA127, BA217, BA218, BA221, BA222, BA317, BA318, BAX13, BAY61, 1N914, 1N4148.
Some **'DUG'**s are: OA85, OA91, OA95, AA116.

- 'BC107B', 'BC237B', 'BC547B' all refer to the same 'family' of almost identical better-quality silicon transistors. In general, any other member of the same family can be used instead.

BC107 (-8, -9) families:
BC107 (-8, -9), BC147 (-8, -9), BC207 (-8, -9), BC237 (-8, -9), BC317 (-8, -9), BC347 (-8, -9), BC547 (-8, -9), BC171 (-2, -3), BC182 (-3, -4), BC382 (-3, -4), BC437 (-8, -9), BC414

BC177 (-8, -9) families:
BC177 (-8, -9), BC157 (-8, -9), BC204 (-5, -6), BC307 (-8, -9), BC320 (-1, -2), BC350 (-1, -2), BC557 (-8, -9), BC251 (-2, -3), BC212 (-3, -4), BC512 (-3, -4), BC261 (-2, -3), BC416.

Resistor and capacitor values
When giving component values, decimal points and large numbers of zeros are avoided wherever possible. The decimal point is usually replaced by one of the following abbreviations:
p (pico-) = 10^{-12}
n (nano-) = 10^{-9}
µ (micro-) = 10^{-6}
m (milli-) = 10^{-3}
k (kilo-) = 10^{3}
M (mega-) = 10^{6}
G (giga-) = 10^{9}
A few examples:
Resistance value 2k7: 2700 Ω.
Resistance value 470: 470 Ω.
Capacitance value 4p7: 4.7 pF, or 0.000 000 000 004 7 F . . .
Capacitance value 10n: this is the international way of writing 10,000 pF or .01 µF, since 1 n is 10^{-9} farads or 1000 pF.
Resistors are ¼ Watt 5% carbon types, unless otherwise specified.
The DC working voltage of capacitors (other than electrolytics) is normally assumed to be at least 60 V. As a rule of thumb, a safe value is usually approximately twice the DC supply voltage.

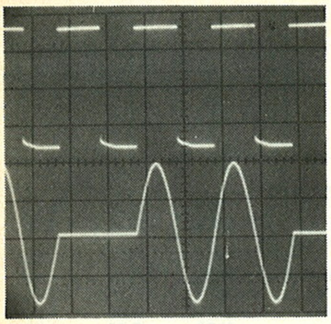
Test voltages
The DC test voltages shown are measured with a 20 kΩ/V instrument, unless otherwise specified.

U, not V
The international letter symbol 'U' for voltage is often used instead of the ambiguous 'V'. 'V' is normally reserved for 'volts'. For instance: U_b = 10 V, not V_b = 10 V.

Mains voltages
No mains (power line) voltages are listed in Elektor circuits. It is assumed that our readers know what voltage is standard in their part of the world!
Readers in countries that use 60 Hz should note that Elektor circuits are designed for 50 Hz operation. This will not normally be a problem; however, in cases where the mains frequency is used for synchronisation some modification may be required.

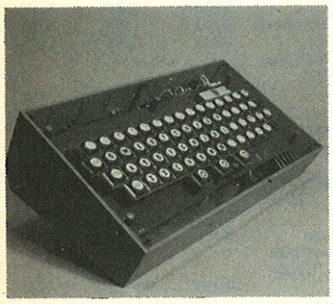
Technical services to readers

- **EPS service.** Many Elektor articles include a lay-out for a printed circuit board. Some — but not all — of these boards are available ready-etched and predrilled. The 'EPS print service list' in the current issue always gives a complete list of available boards.
- **Technical queries.** Letters with technical queries should be addressed to: Dept. TQ. Please enclose a stamped, self addressed envelope; readers outside U.K. please enclose an IRC instead of stamps.
- **Missing link.** Any important modifications to, additions to, improvements on or corrections in Elektor circuits are generally listed under the heading 'Missing Link' at the earliest opportunity.



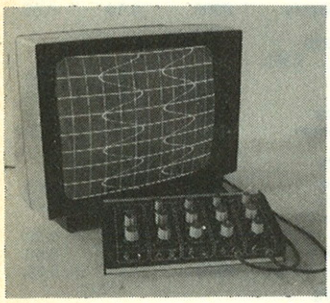
A (repetitive) tone-burst signal is an extremely useful aid for testing audio equipment. Basically, this type of test signal is obtained by switching the output of a sine-wave oscillator on and off at regular intervals. The **tone-burst generator** utilises a novel design approach that simplifies the circuit considerably and only involves one minor reduction of the capabilities.

p. 12-10



The most convenient and elegant method of displaying data from a microprocessor is on a Visual Display Unit (VDU). When used in conjunction with an ASCII keyboard, a video interface circuit forms a complete video data terminal.
The **elekterminal** can be used with the Elektor SC/MP system or any microprocessor system possessing a serial input/output facility.

p. 12-16



Although the basic version of the **TV scope** is an extremely useful tool when testing low-frequency circuits, the **extended version** offers vastly superior display possibilities. Any signal within the frequency range of the scope (DC to 100 kHz) can be displayed as a clear and stable trace on the screen of any domestic TV receiver.

p. 12-34

nr 44
december 1978
UK 50p
USA/Can $1.50

elektor

up-to-date electronics for lab and leisure

ASCII keyboard

plus

elekterminal

equals

TV typewriter

This month's cover illustrates the close relationship between the ASCII keyboard, published last month, and the Elekterminal described in this issue. Although they are two independent units, each useful in its own right, the combination is equal to a 'TV typewriter' with a microprocessor-compatible interface.

contents

selektor **12-01**

PWM audio amplifiers **12-04**
This article takes a look at the principles of class-D amplifiers and examines the circuit of a commercial design.

singing SC/MP **12-08**
It's possible to make a μP sing a tune, as demonstrated in the SC/MP program described here. With Christmas in the air, a well-known tune was chosen: 'Silent Night'. Programs for several other well-known melodies are also included on an ESS record.

tone-burst generator **12-10**

disco drums (L. Witkam) **12-14**
A large number of contemporary pop records are aimed at the so-called 'disco scene'. With the aid of the circuit described here, records from the 'pre-disco era' or one's party tapes can be lent an authentic disco 'flavour' by the addition of a synthesised percussion track.

elekterminal **12-16**

RAM diagnostic (H. Huschitt) **12-25**
The more RAM one adds to a μP system, the more difficult it becomes to trace any faults which may occur on one of the memory boards. The following program can be used to test any block of memory larger than ½ K and will indicate the location of any faults which exist. The complete program is also recorded on the Elektor Software Service record ESS-001.

reading Elektor **12-27**

cumulative index volume 4 – 1978 . . . . **12-28**

TUP/TUN/DUS/DUG **12-30**

variable fuzz-box **12-31**
This super simple circuit can produce a large variety of manually controlled sound effects, by employing signal clipping techniques.

TV scope – extended version **12-34**

extending the elektor piano **12-51**
This article provides readers with details of the changes in component values and of the additions to the filter circuits which will be required to extend the piano with one, two or three octaves.

missing link **12-54**

market **12-54**

advertiser's index . . . . **UK 26**

eps printservice

Many Elektor circuits are accompanied by designs for printed circuits. For those who do not feel inclined to etch their own printed circuit boards, for their own use only, a number of these designs are available as ready etched and pre-drilled boards. Delivery time is approximately three weeks, U.K./air mail.

Example:

$$\underset{1}{\text{digisplay}}\quad\underbrace{\text{(E13)}}_{2}\quad\underbrace{9376}_{3}\underset{4}{\downarrow}\quad\underbrace{3.10}_{5}\underset{6}{\downarrow}\ \underbrace{6.90}_{7}$$

1. Circuit title
2. reference to associated article(s)
3. board number
4. * = p.c.b.'s without solder mask

U.K.:

5. price (in £) inclusive of VAT
6. * = 12.5% VAT; otherwise 8% VAT

U.S.A. and Canada:

7. price in $, not including tax (if any)

		£	$
E1: DECEMBER 1974			
equa amplifier	1499*	1.80$^+$	3.95
E3: APRIL 1975			
disc preamp 76131	4040B*	1.25	2.80
E7: NOVEMBER 1975			
ota pll	6029*	1.40$^+$	3.10
frequency counter, minitron display board	9312	1.45	3.20
frequency counter, led display board	9313	1.45	3.20
frequency counter, counter/latch/display driver	9314	1.20	2.60
E8: DECEMBER 1975			
die	9169	0.85	1.90
E12: APRIL 1976			
stylus balance	9343	0.45$^+$	1.05
rhythm generator (M253AA)	9344-3	1.45$^+$	3.20
ic drummer, instruments mother board	9344-2	2.00$^+$	4.40
ic drummer, instruments daughter board	9344-1	0.35$^+$	0.80
UAA 170, 270° meter, basic board (E17)	9392-1	1.50	3.30
UAA 170, 270° meter, front panel (E17)	9392-2	2.00	4.40
UAA 170, LED voltmeter, basic board	9392-3	1.15	2.50
UAA 170, 16 LED display board	9392-4	0.95	2.10
E13: MAY 1976			
preco, preamplifier	9398	2.40$^+$	5.35
preco, control amplifier	9399	1.40$^+$	3.10
equin	9401	2.55$^+$	5.65
E17: SEPTEMBER 1976			
tachometer, LED meter board (E12)	9392-1	1.50	3.30
tachometer, front panel (E12)	9392-2	2.00	4.40
tachometer, control board	9460	1.45	3.15
windscreen wiper delay, using SCR	9474-1	0.70	1.55
E19: NOVEMBER 1976			
intercom	9156	1.05	2.30
albar: see E25, May 1977			
albar, power supply	9437	1.15	2.50
signal horn	9438	1.05	2.30
E21: JANUARY 1977			
stereo audio mixer	9444	6.55$^+$	14.50
marbles	9753	1.55	3.40
E22: FEBRUARY 1977			
local radio AF	9499-1	0.70$^+$	1.55
local radio psu	9499-2	0.70	1.55
E23: MARCH 1977			
OTA-PLL (E7, E24)	6029	1.40$^+$	3.10
scope calibrator	9455	0.30	0.65
run rabbit, run!	9764	4.15	9.15
E24: APRIL 1977			
digisplay (E13)	9376	3.10	6.90
LED VU/PPM,			
rectifier section	9419-1	2.35$^+$	5.15
display section	9419-2	4.50$^+$	9.95
audio slide changer	9743	0.65	1.45
morse decoder	9759	7.35	16.25
signal injector	9765	0.50	1.10
E25: MAY 1977			
model car track (E24):			
multiplex encoder	9796-1	3.10	6.85
infra-red transmitter	9796-2	1.60	3.55
albar (E19):			
single transducer/receiver	9815-1	1.25	2.80
transmitter	9815-2	0.40	0.85
E26: JUNE 1977			
precision timebase	9448	1.55	3.40
power supply for precision timebase	9448-1	0.60	1.30
formant: keyboard interface (E25)	9721-1	2.60$^+$	5.75
levitator	9763	2.35	5.20
active loudspeaker cross-over filters (E25)	9786	1.95$^+$	4.30
model car track (E24,E25):			
servo amplifier	9803	0.35	0.80
E27/E28: SUMMER CIRCUITS 1977			
knotted handkerchief	9830	0.20	0.45
guitar preamp	77020	1.10$^+$	2.45
0 . . . 10 V supply	77059	0.95	2.10
π-qualiser	77071	0.70$^+$	1.50
automatic NiCad charger	77075	0.65	1.45
TV games	77084	2.05	4.50
4 W car radio amplifier	77101	0.65$^+$	1.40
3½ digit DVM	77109	2.15	4.70
E29: SEPTEMBER 1977			
FM mains intercom	9359	4.85	10.75
formant (E25. E26):			
interface receiver	9721-2	1.30$^+$	2.80
power supply	9721-3	4.15$^+$	9.15
keyboard divider (one octave)	9721-4	0.75$^+$	1.70
logarithmic darkroom timer	9797	1.50	3.35
CCIR test pattern generator, motherboard	9800-1	5.95	13.10
model car track (E24 . . . E26):			
motor speed control	9829-1	0.55	1.20
proptester	9829-2	1.55	3.45
E30: OCTOBER 1977			
CCIR			
daughter board 1 (E29)	9800-2	3.30	7.35
infrared transmitter	9822	2.50$^+$	5.55
ioniser	9823	3.00	6.60
Kirlian camera (two boards)	4523 9831	2.25	5.00
model car track (E24 . . . 26, 29):			
infrared receiver	9848-1	0.80	1.80
multiplex decoder	9848-2	0.85	1.90
E31: NOVEMBER 1977			
formant (E25 . . . E30):			
VCO	9723-1	8.30$^+$	18.35
CCIR: daughter board 2 (E29, E30)	9800-3	2.55	5.65
video biofeedback:			
display generator	9825-1	2.55	5.60
alpha amplifier	9825-2	2.10	4.60
electrometer	9826-1	0.70	1.50
sensors for electrometer	9826-2	0.65	1.40
magnetiser	9827	0.65	1.45
experimenting with the SC/MP:			
RAM-I/O	9846-1	5.75	12.70
SC/MP board	9846-2	1.80	3.95
model car track (E24 . . . E30):			
transmitter power supply	9218	1.00	2.20
chassis	9850	2.85	6.35
E32: DECEMBER 1977			
formant (E25 . . . E31):			
VCF	9724-1	3.40$^+$	7.45
experimenting with the SC/MP (E31): CPU	9851a	8.50	18.80
UHF TV modulator	9864	1.35	2.95
electret microphone preamplifier	9866	0.60$^+$	1.30
analogue frequency meter	9869	1.10	2.40
heating controller	9877	3.20	7.05
MW reflex receiver	9880	0.85	1.85
sensitive lightmeter	9886	0.60	1.30
stylus balance (E12)	9343	0.45$^+$	1.05
signal injector (E24)	9765	0.50	1.10
knotted handkerchief (E27/E28)	9830	0.20	0.45
E33: JANUARY 1978			
simple function generator	9453	2.70	6.00
formant (E25 . . . E32):			
ADSR	9725-1	3.20	7.05
UAA 180 LED voltmeter	9817	1.75	3.90
elektor equaliser	9832	3.45$^+$	7.65
experimenting with the SC/MP (E31, E32):			
bus board	9857	3.00	6.65
memory card	9863	12.75	28.20
CMOS noise generator	9859	1.45	3.20
peak programme meter	9860	1.30$^+$	2.80
E34: FEBRUARY 1978			
formant (E25 . . . E33):			
DUAL-VCA	9726-1	3.35	7.40
development timer	9840	2.10	4.60
experimenting with the SC/MP (E31 . . . E33):			
HEX I/O	9893	17.00	37.60
infra-red light gate:			
transmitter	9862-1	0.65	1.40
receiver	9862-2	0.85	1.85
E35: MARCH 1978			
formant (E25 . . . E34):			
LFO module	9727-1	3.55	7.90
noise module	9728-1	3.05	6.75
4 k RAM card	9885	14.90	32.90
colour TV games:			
VHF games board	9892	2.10	4.65
UHF converter	9864	1.35	2.95
SC/MP power supply	9906	3.10	6.85
E36: APRIL 1978			
formant (E25 . . . E35):			
COM	9729-1	2.80$^+$	6.20
elektornado	9874	2.95$^+$	6.50
cassette interface	9905	2.50	5.50
moving coil preamp	9911	3.30$^+$	7.35
E37: MAY 1978			
colour modulator	9873	1.80	3.95
percolator switch	9902	0.85	1.85
digital reverberation unit,			
main board	9913-1	4.15$^+$	9.20
extension board	9913-2	1.20$^+$	2.60
mini shortwave receiver	9920	1.50$^+$	3.35
E38: JUNE 1978			
1/4 GHz counter			
timebase and control	9887-1	7.85	17.40
counter and display	9887-2	8.95	19.75
low freq. input amp	9887-3	1.40	3.05
high freq. input amp	9887-4	1.30	2.90
automatic mono/stereo switch	9923	0.90$^+$	2.00
TV sound modulator	9925	0.95	2.05
mini-counter	9927	2.50	5.50
E39/40: SUMMER CIRCUITS 1978			
power flasher	78003	0.80	1.75
electronic gong	78037	1.05	2.35
bicycle speedometer	78041	0.85	1.85
glowplug regulator	78042	1.75	3.90
touch dimmer	78065	0.75	1.65
micropower amplifier	9558	1.00	2.15
consonant	9945	6.40	14.10
luminant (3 boards)	9949	6.05	13.35
preconsonant	9954	2.00	4.40
E41: SEPTEMBER 1978			
piano			
octave	9914	3.15$^+$	7.00
power supply	9979	1.70$^+$	3.80
filter	9981	4.25$^+$	9.40
master tone generator	9915	7.55$^+$	16.70
temperature-controlled soldering iron	9952	1.60	3.55
formant			
24 dB VCF	9953-1	4.00$^+$	8.80
puffometer	9961	1.50	3.30

ORDERING INFORMATION **Payment must be in advance.**

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eps printservice

E42: OCTOBER 1978

central alarm system:			
master station	9950-1	2.45	5.40
slave station	9950-2	2.15	4.75
alarm station	9950-3	1.05	2.35
resonance filter module	9951	3.70+	8.25
VHF/UHF modulator	9967	1.35	2.95
TV-scope:			
Y-amplifier	9968-1	1.80	3.90
main board	9968-2	3.40	7.50
video mixer	9968-3	1.70	3.80
sync circuit	9968-4	1.70	3.80
power supply	9968-5	1.35	2.95
databus buffer	9972	1.35	2.95
analogue reverberation unit	9973	4.85+	10.65
proximity detector	9974	2.25	5.00

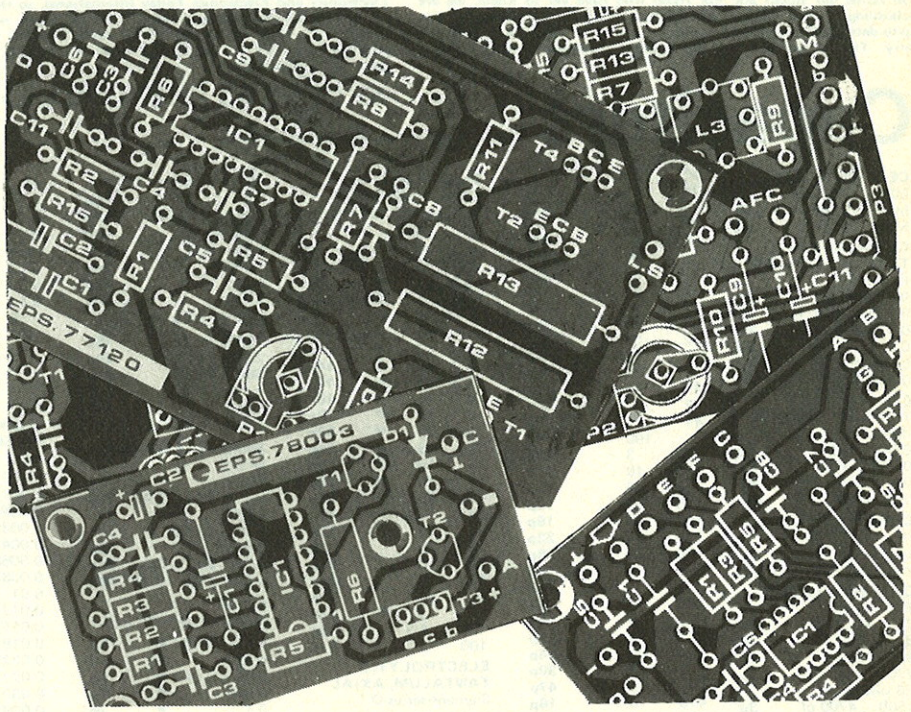
E43: NOVEMBER 1978

digiscope, main board	9926-1	4.80	10.65
digiscope, display board	9926-2	1.35	2.95
ASCII keyboard	9965	6.50	14.35
cackling egg-timer	9985	1.85	4.05
loudspeaking telephone,			
main board	9987-1	1.50	3.30
pick-up board	9987-2	1.35	2.95
pocket bagatelle	9988	1.35	2.95
ring the bell and win a prize	79006	1.60	3.55
Tag!	79007	1.65	3.30

NEW

E44: DECEMBER 1978

elekterminal	9966	10.85	23.95
TV scope (E42,E43):			
memory board	9969-1	4.25	9.40
trigger board	9969-2	1.35	2.95
timebase board	9969-3	1.35	2.95
tone-burst generator	79017	2.35	5.20



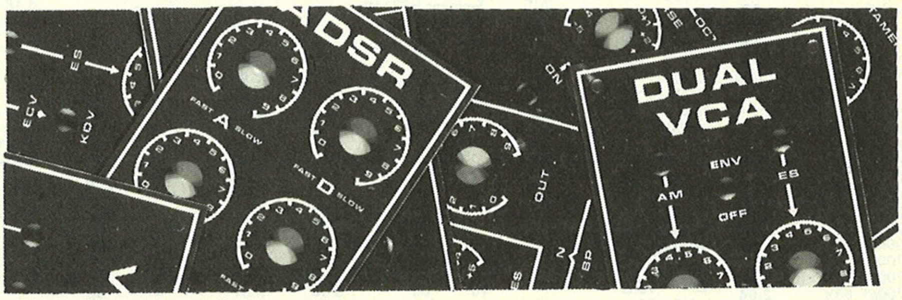
eps front panels

front panels for Formant (E25 . . . E35)

interface	9721-F	1.40	3.05
VCO	9723-F	1.40	3.05
VCF	9724-F	1.40	3.05
ADSR	9725-F	1.40	3.05
DUAL-VCA	9726-F	1.40	3.05
LFOs	9727-F	1.40	3.05
NOISE	9728-F	1.40	3.05
COM	9729-F	1.40	3.05

Complete set of 11 panels (includes 3 x VCO and 2 x ADSR): £ 13.85 or $ 30.55.

24 dB VCF (E41)	9953-F	1.40	3.05
resonance filter module (E42)	9951-F	1.40	3.05
simple function generator (E33, E38)	9453-F	1.50	3.30
consonant (E41)	9945-F	4.25+	9.40



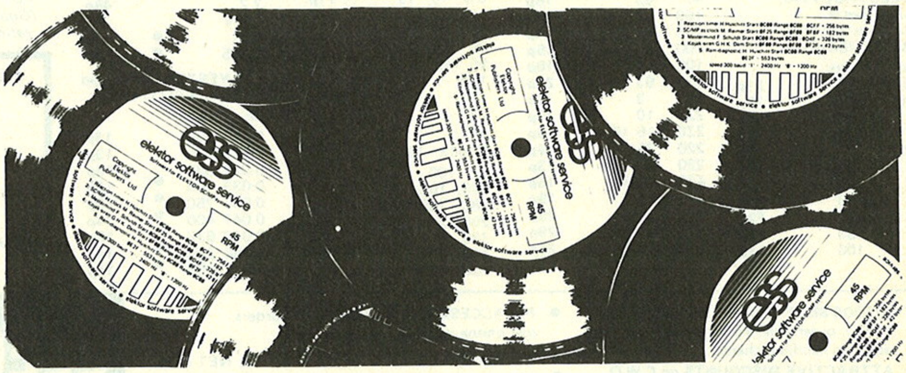
ess software service

45 RPM records with SC/MP programmes

reaction timer, SC/MP as clock, mastermind, Kojak siren, RAM diagnostic	ESS 001	1.05	2.35

NEW

singing SC/MP: well-known Christmas melodies, both as SC/MP program and 'live'	ESS 002	p.o.a.



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ELECTROVALUE Buying Guide

Section 2

If you have bought from us before, you will know just how large and varied our stocks are. For those who have yet to know, we are publishing a series of five advertisements month by month to give up-to-date information and prices on the most important items we carry. These advertisements will appear in stepped rotation in five journals – Elektor, Practical Wireless, Practical Electronics, Everyday Electronics and Electronics Today International, so that the complete series will be available each month. In this way, no matter which journals you read, BY DETACHING AND SAVING THESE PAGES, YOU WILL HAVE A VALUABLE AND COMPREHENSIVE MONEY SAVING CATALOGUE.

MEET US AT BREADBOARD STAND No. B8

Capacitors

Quantity prices available except for MDC.

CERAMIC DISC ●

500V: 1, 2, 5nF.	3p
50V: 0.02μF	3p
50V: 0.05μF	4p

CERAMIC FLAT TUBULAR B37448 ●
(2.5mm)

0.01μF 63V	4p
0.022μF 40V #	3p
0.022μF 63V	5p
0.033μF 63V	5p
0.047μF 63V	5p
0.068μF 63V	6p

CERAMIC FLAT TUBULAR B37449 ●
(5mm)

0.047μF 63V	5p
0.068μF 63V	5p
0.1μF 63V	6p
0.22μF 63V	11p

CERAMIC PLATE
(Mullard C333) ●
E12 values

1.8pF – 18pF	4p

CERAMIC PLATE ●

E12 values	
22 – 33 pF	3p
39 – 68 pF	3p
82 – 220 pF	3p
270 – 1000 pF	3p
E6 values	
1500 – 4700 pF	3p
6800 pF	3p

CERAMIC FEED THROUGH ●

1000pF 350V	6p

ELECTROLYTIC, REVERSIBLE ●
EX50 series, 50V

2μF	25p
4, 6μF	27p
8, 10, 16μF	30p
25μF	35p
40, 60μF	56p
100μF	65p

ELECTROLYTIC, CANS ●
Siemens B41070
unsleeved

1000μF 40V	99p
1000μF 63V	1.07
1000μF 100V	1.50
2200μF 25V	1.08
2200μF 40V	1.21
2200μF 63V	1.50
4700μF 25V	1.46
4700μF 40V	1.50
4700μF 63V	2.04

ELECTROLYTIC, CANS ●
Daly, *sleeved*

1000/25	46p
2200/50	94p
5000/25	98p
4700/100	3.61

ELECTROLYTIC, axial lead ●
Siemens B41313/B41283/B41010

μF	volts	
0.47	63	21p
0.47	100	12p
1.0	40	21p
1.0	100	12p
2.2	25	12p
2.2	63	12p
2.2	100	12p
4.7	16	21p
4.7	40	12p
4.7	63	12p
4.7	100	14p

μF	volts	
10	6.3	21p
10	25	12p
10	40	12p
10	63	14p
10	100	15p
22	10	12p
22	25	12p
22	40	13p
22	63	15p
22	100	16p
47	3	12p
47	10	12p
47	25	14p
47	40	15p
47	63	16p
47	100	19p
100	3	12p
100	10	14p
100	16	15p
100	25	16p
100	40	16p
100	63	22p
100	100	28p
220	3	13p
220	6.3	15p
220	10	15p
220	16	17p
220	25	20p
220	40	24p
220	63	30p
220	100	47p
470	6.3	16p
470	10	19p
470	16	24p
470	25	22p
470	40	31p
470	63	49p
470	100	74p
1000	3	18p
1000	6.3	22p
1000	10	21p
1000	16	30p
1000	25	40p
1000	40	45p
1000	63	76p
2200	3	23p
2200	10	30p
2200	16	45p
2200	25	70p
2200	40	77p
4700	16	85p
4700	25	96p
10,000	3	40p

ELECTROLYTIC, PLUGGABLE ●
Siemens B41316 series

μF	volts	
1.0	63	13p
2.2	63	13p
4.7	63	13p
10	63	13p
22	40	13p
22	63	14p
47	16	13p
47	40	14p
47	63	18p
100	6.3	14p
100	16 16	14p
100	25	15p
100	40	18p
100	63	24p
220	3	8p
220	10	16p
220	16 16	18p
220	25	19p
220	40	23p
470	6.3	16p
470	10	19p
470	25	25p
470	40	29p
1000	16	26p

ELECTROLYTIC, TANTALUM BEAD
Siemens B45134 series

μF	volts		
0.1	35	●	14p
0.15	35	●	12p
0.22	35	●	14p
0.47	35	●	14p
0.68	35	●	14p
1.0	35	●	14p
2.2	16	●	14p
2.2	35	●	14p
3.3	16	●	14p
4.7	16	●	16p
4.7	35	●	18p
6.8	25	●	18p
10	6.3	●	16p
10	16	●	18p
10	25	●	20p
15	25		31p
22	6.3	●	18p
22	16		22p
22	25		45p
33	10		22p
47	6.3		22p
47	16		35p
100	3	●	22p
100	6.3		45p
100	10		67p

ELECTROLYTIC, TANTALUM, AXIAL
Siemens series D

0.1/35, 0.47/35,	35p
1/35	35p
2.2/20, 4.7/10	35p
2.2/35, 4.7/35	37p
10/20, 22/15	37p
47/10	66p

LACQUER FILM
(non-polarised)
Siemens B32110
series 20% tol.

μF	volts	
0.1	100	76p
0.15	63	62p
0.22	63	65p
0.33	63	70p
0.47	63	78p
0.68	63	84p
1.0	63	91p
1.0	100	1.45
1.0	250	2.01
1.5	63	93p
2.2	63	1.60
3.3	63	1.82
4.7	63	2.07
6.8	63	2.59
10	63	3.00
10	100	5.06

SILVERED MICA, 350V ●
1% (or ½pF)
R611, 12.7 x 8mm
All in pF.

2.2 3.3, 5	11p
6.8, 10, 15	11p
18, 20, 22, 25	11p
27, 30, 33	11p
39, 47, 50	11p
56, 68	11p
100	12p
150	14p
220	17p
330	20p

R1015, 16.5 x 11.4mm

82, 100	11p
120, 150	11p
180, 200, 220	12p
250, 270, 300	12p
330	15p
470	16p
1000	20p

R1524, 28.0 x 17.8mm

330	18p
390, 470, 500	18p
560, 680	18p
820, 1000	22p
2200	24p
3300	36p
4700	46p

R2032, 35.6 x 23.0mm

1500, 1800	18p
2200, 2700	24p
3600, 3900	29p
4700, 5000	33p
6800	41p
8200, 10,000	56p

MIXED DIELECTRIC,
M.D.C

600V

0.1	27p	0.47	72p

1000V

0.001, 0.0022,			18p
0.0047			18p
0.01	20p	0.022	21p
0.1	27p	0.22	48p

POLYESTER,
Mullard C280, PC mtg.

0.01, 0.015	●	6p
0.022	●	6p
0.033, 0.047	●	6p
0.068	●	7p
0.1	●	7p
0.15	●	8p
0.22	●	9p
0.33	●	13p
0.47	●	15p
0.68, 1.0		24p
1.5, 2.2		42p

POLYESTER,
PC mounting
Mullard 344- or Siemens B32234- series as available

100V		
0.047	●	9p
0.068	●	9p
0.1	●	10p
0.15	●	11p
0.22	●	12p
0.33	●	16p
0.47	●	18p
0.68		22p
1.0		27p
2.2		46p
4.7		79p
6.8		1.08
250V		
0.01	●	6p
0.015	●	6p
0.022	●	8p
0.033	●	8p
0.047	●	8p
0.1	●	11p
0.68		24p
0.82		24p
1.0		27p
2.2		48p
400V		
0.01	●	7p
0.015	●	7p

POLYESTER, Axial lead
Siemens B32231 series

μF	volts		
0.01	630		13p
0.015	630		13p
0.022	630		13p
0.033	400	●	13p
0.047	250	●	13p
0.047	400	●	14p
0.047	630		16p
0.068	250	●	14p
0.1	250	●	14p

μF	volts		
0.1	400	●	15p
0.1	630		25p
0.12	250	●	13p
0.15	250	●	14p
0.22	250	●	15p
0.33	250	●	18p
0.47	250	●	21p
0.68	250		27p
1.0	250		31p
1.0	400		46p
2.2	250		51p
4.7	250		1.04
10	250		1.81

POLYESTER,
B32560 PCM 7.5mm

μF	volts		
0.001	250	●	6p
0.0015	250	●	6p
0.0022	250	●	6p
0.0033	250	●	6p
0.0047	250	●	6p
0.0068	250	●	6p
0.0082	250	●	7p
0.01	250	●	6p
0.012	250	●	7p
0.015	250	●	6p
0.018	250	●	8p
0.022	250	●	7p
0.027	250	●	8p
0.033	250	●	7p
0.039	250	●	8p
0.047	250	●	7p
0.056	250	●	9p
0.068	250	●	8p
0.082	250	●	11p
0.1	250	●	9p
0.1	100	●	9p
0.12	100	●	12p
0.15	100	●	10p
0.18	100	●	14p
0.22	100	●	12p
0.27	100	●	19p
0.33	100	●	16p
0.39	100	●	23p
0.47	100	●	20p
0.56	100		30p
0.68	100		25p

POLYESTER,
B32561 PCM

0.01	250	●	5p
0.022	250	●	6p
0.047	250	●	7p
0.1	250	●	9p
0.22	100	●	11p
0.47	100	●	17p
1.0	100		28p

POLYESTER,
B32562 PCM

0.47	100	●	17p
1.0	100		30p
2.2	100		48p

POLYESTER,
B32563 PCM

1.0	400	72p

(Good pulse discharge ratings)

POLYPROPYLENE,
B33063, 160V ●

100, 470, 680pF	4p
2200, 4700, 5600pF	6p
5100pF	4p
6800, 10,000pF	6p

POLYSTYRENE,
B31110, 160V

5, 7, 10, 12pF	6p
15, 22, 27, 33pF	6p
39pF	6p
47, 56, 68, 82pF	5p
100, 120, 150pF	5p
160, 180, 220pF	5p
270, 330, 390pF	5p
470, 560pF	5p

POLYSTYRENE,
31310, 160V

560, 680, 820pF	5p
1000, 1500pF	5p
2200 3300pF	5p
1200, 1800pF	8p
2700, 3900pF	8p
4700, 5600pF	8p
6800, 8200pF	8p
10,000pF	8p
12,000, 15,000pF	12p
18,000, 22,000pF	13p

TRIMMER CAPACITORS

Polypropylene, 100V, 0.1"matrix ●

2-10pF	23p
5.5-65pF	34p
2-22pF	27p

VARIABLE CAPACITORS

Jackson 'Dilicon' solid dielec.

100pF	1.70	200pF	1.82
300pF	1.96	500pF	2.20

Jackson C804, air dielectric

5pF	1.39	60pF	1.66
20pF	1.48	150pF	1.89
50pF	1.48	15pF	1.39
100pF	1.71	30pF	1.66
10pF	1.39	75pF	1.66
25pF	1.39		

Jackson Ball Drives, 6:1

4511BD	1.38
4511DA	1.38
4489 with calibrated dial	4.88

CAPACITOR CLIPS

HORIZONTAL

25mm	8p	35mm	8p
44mm	11p		

VERTICAL

25mm	8p	30mm	14p
35mm	8p	41mm	8p
44mm	10p	51mm	14p
64mm	14p#		

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High stability, low noise, 0.25W 5% E12 series from 4.7 ohms to 10 Megohms. Any selection.

each	100+	1000+	5000+
1p	**0.9p**	**0.8p**	**0.75p**

Special development pack of 10 of each value 4.7 ohms to 1 Megohm, a total of 650 resistors **£5.70**

Potentiometers

Carbon track. Log and Linear values
5K – 2M2 single gang **26p**
5K – 2M2 single gang switched **60p**
5K – 2M2 dual gang stereo **75p**

Preset Potentiometers

Subminiature type available in horizontal or vertical mounting. 0.1W rating. 100 ohms to 2M. .... **6p each.**

Special development of 5 of each value from 100 ohms to 2M, a total of 70 presets (please state vertical or horizontal) **£3.95**

Ceramic Capacitors

Miniature plate type. 50V PC mounting. Available from 22pF to 1000pF in E12 series and 1500pF to 0.047uF in E6 series. .... **2p each.**

Polyester Capacitors

Mullard C280 series. 250V PC mounting.
0.01, 0.015, 0.022, 0.033, 0.047, 0.048, 0.1, **5p**; 0.15, 0.22, **7p**; 0.33, 0.47, **10p**; 0.068, **14p**; 1.0, **17p**; 2.2uF, **28p each.**

Special development pack of 5 of each value **£6.20**

Tantalum Capacitors

0.1, 0.15, 0.22, 0.33, 0.47, 0.68, 1.0, 2.2 @ 35V **9p**
4.7 @ 25V, 6.8 and 10 @ 25V **13p**
22 @ 16V, 47 @ 6V, 68 @ 3V, 100 @ 3V **16p**
Development pack 5 of each value **£8.30**

Optoelectronics

LEDs

	Red	Green	Yellow
0.125 in	**9p**	**15p**	**18p**
0.2 in	**9p**	**13p**	**18p**

Displays

DL707	**90p**	DL704	**90p**

DIL Sockets

8 pin	**11p**	14 pin	**12p**	16 pin	**13p**	24 pin	**30p**

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CA3043	180p	NE560	300p
CA3046	75p	NE561B	350p
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4010	35p	4050	28p
4011	15p	4051	55p
4012	15p	4052	55p
4013	35p	4066	40p
4015	60p	4068	20p
4016	35p	4069	16p
4017	55p	4070	16p
4018	65p	4071	16p
4020	60p	4072	16p
4022	55p	4073	16p
4023	15p	4075	16p
4024	45p	4078	16p
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7433	32p	74156	52p
7437	22p	74157	53p
7438	22p	74160	60p
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7441	52p	74162	65p
7442	43p	74163	65p
7443	75p	74164	70p
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7445	70p	74166	80p
7446	55p	74167	180p
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7448	58p	74172	400p
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7451	14p	74174	68p
7452	13p	74175	65p
7454	14p	74176	58p
7460	14p	74177	58p
7470	28p	74178	80p
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AC126	18p	BC559	13p	ZTX310	13p	2N3705	9p
AC127	17p	BCY70	14p	ZTX311	14p	2N3706	9p
AC128	16p	BCY71	14p	ZTX314	22p	2N3707	9p
AC176	18p	BCY72	14p	ZTX341	21p	2N3708	8p
AC186	24p	BD115	52p	ZTX500	16p	2N3709	8p
AD161	38p	BD131	35p	ZTX501	16p	2N3710	8p
AD162	38p	BD132	35p	ZTX502	20p	2N3711	8p
AF124	27p	BD133	44p	ZTX503	20p	2N3715	10p
AF125	27p	BD135	38p	ZTX504	25p	2N3819	22p
AF126	27p	BD136	36p	ZTX530	30p	2N3823	65p
AF127	27p	BD137	38p	ZTX550	24p	2N3824	75p
AF139	36p	BD138	38p	2N696	32p	2N3866	55p
AF239	40p	BD139	35p	2N697	12p	2N3903	8p
BC107	8p	BD140	35p	2N698	28p	2N3904	8p
BC107B	10p	BF244B	36p	2N699	50p	2N3905	8p
BC108	8p	BFX29	25p	2N706	13p	2N3906	8p
BC108B	8p	BFX84	23p	2N706A	13p	2N4037	30p
BC108C	10p	BFX87	20p	2N708	20p	2N4058	12p
BC109	8p	BFX88	20p	2N914	22p	2N4059	10p
BC109C	10p	BFY50	15p	2N918	30p	2N4060	12p
BC147	7p	BFY51	15p	2N919	50p	2N4061	12p
BC148	7p	BFY52	15p	2N920	54p	2N5179	50p
BC149	8p	BU105	170p	2N929	25p	2N5457	22p
BC157	9p	BU205	140p	2N930	20p	2N5458	30p
BC158	9p	BU208	160p	2N1131	23p	2N5459	32p
BC159	9p	MJ2955	98p	2N1132	23p	2N5777	50p
BC167	8p	MPF102	36p	2N1302	38p		
BC168	8p	MPSA06	30p	2N1303	54p	**Diodes**	
BC169	8p	MPSA56	30p	2N1304	54p	OA47	10p
BC169C	9p	TIP29	40p	2N1613	22p	OA91	5p
BC170	9p	TIP29A	44p	2N1671	130p	OA200	6p
BC171	9p	TIP29B	40p	2N2160	100p	1N914	4p
BC172	7p	TIP29C	60p	2N2243	28p	1N916	5p
BC173	9p	TIP30	40p	2N2297	45p	1N4001	4p
BC177	14p	TIP30A	48p	2N2368	15p	1N4002	4p
BC178	14p	TIP30B	55p	2N2369	16p	1N4006	6p
BC179	14p	TIP30C	70p	2N2484	22p	1N4148	3p
BC182	10p	TIP31	50p	2N2846	70p		
BC182L	10p	TIP31A	50p	2N2904	22p	**Regulators**	
BC183	10p	TIP31B	60p	2N2094A	23p	7805	60p
BC183L	10p	TIP31C	65p	2N2905	22p	7812	60p
BC184	10p	TIP32	55p	2N2905A	22p	7815	60p
BC184L	10p	TIP32A	60p	2N2906	22p	7818	60p
BC207	10p	TIP32B	75p	2N2906A	22p	7824	60p
BC208	8p	TIP32C	80p	2N2907	22p	78L05	30p
BC209C	10p	TIP33	75p	2N2907A	25p	78L12	30p
BC212	10p	TIP33A	80p	2N2926G	10p	78L15	30p
BC212L	10p	TIP33B	103p	2N2926R	8p	7905	80p
BC213	10p	TIP33C	116p	2N3011	22p	7912	80p
BC213L	10p	TIP34	98p	2N3053	18p	7915	80p
BC214	10p	TIP34A	95p	2N3054	50p	7918	80p
BC214L	10p	TIP34B	128p	2N3055	50p	7924	80p
BC477	19p	ZTX107	14p	2N3121	25p	79L05	70p
BC478	18p	ZTX108	14p	2N3133	25p	79L12	70p
BC479	18p	ZTX109	14p	2N3440	80p	79L15	70p
BC547	11p	ZTX300	16p	2N3441	120p	LM309K	110p
BC548	10p	ZTX301	16p	2N3442	135p	LM317K	300p
BC549	11p	ZTX302	23p	2N3702	8p	LM323K	530p
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.0022	.03	.1	.045
.0047	.03	.22	.04
.01	.03	.47	.085
.022	.035	.68	.085

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1	63V	.06
2.2	63V	.06
4.7	63V	.05
6.8	40V	.06
10	25V	.05
10	63V	.07
10	100V	.085
47	10V	.02
47	25V	.06
47	100V	.09
100	16V	.06
100	25V	.089
100	63V	.10
220	25V	.095
220	63V	.15
470	6.3V	.03
470	25V	.125
680	16V	.20
1000	16V	.09
1000	25V	.17
2200	25V	.40
2200	40V	.46
4700	25V	.62

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.15	35V	.10
.22	35V	.10
.33	35V	.10
.47	35V	.10
.68	35V	.10
1	35V	.10
1.5	35V	.10
2.2	16V	.10
2.2	35V	.11
3.3	16V	.10
10	6.3V	.08
4.7	10V	.10
4.7	35V	.125
6.8	35V	.125
10*	16V	.10
10	25V	.16
10	35V	.16
15	16V	.14
15*	25V	.12
22*	10V	.11
22	16V	.18
22	35V	.20
33	10V	.18
47	6.3V	.16
47	10V	.16
47	16V	.20
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BC147A/B	.12	.104	.088
BC149	.12	.104	.088
BC157/8/9	.13	.114	.108
BC169C	.08	.073	.057
BC172B	.09	.08	.076
BC177B	.14	.125	.106
BC178/9	.16	.137	.115
BC187	.24	.217	.182
BC213/B	.09	.08	.067
BC237	.12	.104	.088
BC238/A/B	.10	.081	.069
BC238C	.12	.104	.088
BC328	.11	.091	.077
BC337	.11	.091	.077
BC338	.11	.095	.08
BC516/7	.23	.205	.173
BC547/A/B	.10	.081	.069
BC548	.11	.091	.077
BC549	.10	.081	.069
BC556	.14	.119	.101
BC557/A/B	.11	.091	.077
BC558	.13	.112	.094
BC559/B/C	.11	.091	.077
BCY58/9	.17	.148	.125
BCY70/1/2	.19	.171	.144
BCY78	.15	.133	.105
BD234	.57	.509	.429
BF224	.16	.14	.118
BF241	.16	.14	.118
BF244B	.21	.188	.158
BF257	.30	.273	.23
BF258	.31	.285	.24
BF337	.32	.285	.24
BFR39	.16	.146	.123
BFR40	.16	.142	.12
BFR41	.16	.146	.123
BFR52	.15	.133	.112
BFR79	.16	.146	.123
BFR81	.16	.146	.123
BFX29/30	.29	.262	.221
BFX84/5/6	.28	.25	.211
BFX87/8	.28	.25	.211
BFY50/1/2	.27	.237	.20
BU105	1.25	1.13	.955
BU108	1.60	1.44	1.219
BU205	1.33	1.21	1.019
BU208	1.60	1.44	1.219
C1509	.42	.38	.32
MJE340	.74	.703	.555
MPSA05/6	.21	.182	.154
MPSA12	.26	.228	.192
MPSA56	.21	.182	.154
R2008B	1.54	1.34	1.136
R2010B	1.27	1.14	.968
TIP29	.33	.305	.258
TIP29A	.36	.323	.272
TIP29B	.39	.351	.296
TIP29C	.43	.387	.326
TIP30	.36	.323	.272
TIP30A	.38	.34	.286
TIP30B	.41	.37	.312
TIP31B	.43	.389	.328
TIP31C	.48	.427	.36
TIP32	.40	.357	.301
TIP32B	.45	.41	.346
TIP32C	.50	.45	.379
TIP33C	.74	.668	.563
TIP34	.65	.587	.494
TIP34A	.69	.619	.522
TIP34B	.75	.674	.568
TIP35B	1.50	1.35	1.138
TIP36A	1.48	1.33	1.133
TIP36B	1.63	1.46	1.235
TIP41A	.54	.48	.405
TIP41B	.79	.714	.602
TIP41C	.64	.575	.485
TIP42A	.56	.503	.397
TIP42B	.61	.551	.435
TIP42C	.67	.604	.477
TIS90	.14	.119	.101
TIS91	.15	.136	.115
2N696	.25	.218	.178
2N918	.38	.342	.288
2N1131	.26	.235	.198
2N1132	.30	.269	.227
2N1613	.21	.19	.16
2N1711	.27	.237	.20
2N1893	.36	.321	.27
2N2218	.34	.304	.256
2N2218A	.30	.266	.224
2N2219	.28	.25	.211
2N2219A	.39	.347	.293
2N2221	.27	.237	.20
2N2221A	.21	.182	.154
2N2222	.18	.159	.134
2N2222A	.33	.298	.251
2N2368	.18	.159	.134
2N2369	.19	.171	.144
2N29048	.29	.258	.218
2N2905	.33	.294	.248
2N2905A	.35	.317	.267
2N2906	.22	.191	.162
2N2906A	.21	.19	.16
2N2907	.18	.159	.134
2N2907A	.21	.19	.16
2N3053	.25	.222	.187
2N3055	.90	.811	.683
2N3702/3/4	.09	.079	.067
2N3705/7/9	.10	.083	.07
2N3706/8	.09	.171	.144
2N3820	.59	.526	.443
2N3825	.66	.594	.501
2N3903	.09	.081	.069
2N3904/5	.16	.144	.118
2N3906	.17	.148	.125
2N4036	.32	.285	.24
2N4037	.29	.262	.221
2N4058	.10	.091	.077
2N4059	.09	.077	.066
2N4060	.11	.093	.078
2N4061	.10	.091	.077
2N4062	.11	.098	.083
2N4123	.10	.087	.074
2N4124	.31	.273	.23
2N4125	.11	.095	.08
2N4126	.30	.267	.226
2N4236	.31	.273	.23
2N4239	1.30	1.18	.995
2N4292	.13	.114	.096
2N5172	.10	.091	.077
2N5245	.33	.298	.251
2N5296	.48	.433	.365
2N5458	.10	.091	.077
2N5460	.39	.35	.291
3N201	.58	.52	.438
RCA40347	.92	.828	.698
40360	.45	.40	.34
40361	.47	.423	.357
40362	.50	.452	.381
40407	.59	.53	.447
40408	.92	.828	.698
40411	3.88	3.515	2.96
40412	.68	.613	.517
40672	1.00	.902	.76
40841	.77	.689	.581
40871	.94	.849	.716
40872	1.06	.955	.805
4024B	.93	.836	.704
4025A	.19	.171	.144
4027A	.45	.399	.336
4028B	.84	.76	.64
4029A	1.20	1.08	.912
4030B	.45	.399	.336
4042B	1.18	1.06	.896
4043B	.86	.779	.656
4044B	.80	.722	.608
4050B	.80	.722	.608
4051B	.44	.399	.336
4068/9B	1.24	1.12	.944
4071B	.19	.171	.144
4098B	.19	.171	.144
4507A	1.67	1.51	1.272

TTL	1+	25+	100+
7400	.16	.144	.122
7401	.19	.167	.141
7401A	.21	.182	.154
7403	.19	.167	.141
7404	.16	.144	.122
7405	.20	.178	.15
7406	.27	.239	.202
7409	.20	.178	.15
7410	.16	.144	.122
7411	.21	.19	.15
7412	.20	.18	.152
7412A	.22	.195	.165
7413	.32	.288	.243
7416	.24	.216	.182
7417	.24	.216	.182
7420	.16	.144	.122
7421	.31	.285	.225
7425	.21	.182	.154
7426	.21	.19	.16
7430	.16	.144	.122
7432	1.8	.155	.131
7437/8	.20	.18	.152
7440	.16	.144	.122
7441A	.74	.665	.56
7443	.44	.392	.33
7447	.40	.355	.299
7448	.32	.285	.24
7450/1/3	.19	.167	.141
7454	.19	.167	.141
7470/2	.34	.30	.253
7473/4	.26	.228	.192
7476	.31	.273	.23
7480	.36	.321	.27
7481/2	.57	.513	.432
7483	.31	.273	.23
7484	.45	.40	.338
7486/90	.20	.178	.15
7491A	.20	.275	.232
7492	.31	.275	.232
7493	.20	.178	.15
7494	.40	.355	.299
7495	.23	.205	.173
7496	.34	.307	.259
74107/9	.35	.313	.264
74118	.89	.803	.677
74122	.44	.393	.331
74123	.42	.38	.32
74130	1.05	.95	.75
74135	.45	.399	.315
74137	.25	.222	.187
74145	.36	.321	.27
74150	.45	.40	.338
74151/3	.29	.258	.218
74156	.36	.321	.27
74157	.29	.258	.218
74161/3/4	.36	.321	.27
74167	1.26	1.14	.963
74174	.54	.488	.411
74180	.40	.355	.299
74181	.99	.893	.752
74182	.40	.355	.299
74191	.31	.279	.235

CMOS	1+	25+	100+
4000A	.19	.171	.144
4001A	.19	.171	.144
4011/12A	.19	.171	.144
4013B	.45	.399	.336
4014A	.95	.855	.72
4017A	1.03	.931	.784
4018B	1.18	1.06	.896
4021/22A	1.03	.931	.784
4023A	.19	.171	.144

Linear			
CA3018	.92	.824	.695
CA3046	.87	.78	.658
CA3048	2.90	2.63	2.216
CA3080E	.83	.75	.632
CA3130E	1.12	1.00	.852
CA3130T	1.20	1.08	.912
CA3140E	.46	.416	.351
CA3160E	1.20	1.08	.912
CN139DXH	1.00		
D204A-2	6.70		
LM301AN	.32	.281	.237
LM318	1.58	1.43	1.207
LM324	.60	.543	.458
LM380	.55	.494	.39
MC1310P	1.58	1.42	1.20
MC1458P	.34	.304	.261
MC3340P	1.95	1.76	1.389
MC7242P	.46	.416	.351
NE444P	.30	.279	.236
NE556	.57	.513	.432
SFC2741	.25	.228	.192
SN76110	.73	.657	.554
SN76023	1.73	1.55	1.31
SN76227	.94	.845	.712
SN76660	.51	.456	.384
TAA621A	2.73	2.47	2.08
TBA641B11	1.30	1.15	.976
TBA800	.70	.627	.528
TBA920	1.53	1.37	1.16
TDB555	.30	.266	.224
UA733CN	.68	.609	.514
UA741CP	.28	.262	.221
UA747	.80	.716	.603
UA748	.42	.376	.316
SN15332	.25	.228	.18.

DDL Sockets	1+	25+	100+
8 pin	.13	.112	.094
14 pin	.14	.123	.104
16 pin	.16	.138	.116
18 pin	.22	.193	.163
20 pin	.23	.203	.171
22 pin	.25	.224	.188
24 pin	.26	.233	.196
28 pin	.34	.307	.259
40 pin	.49	.437	.368

Voltage Regs			
2805EC	.82	.585	.741
2812EC	.82	.585	.741
2905SP	.82	.585	.741
78M15CKD	.52	.367	.465
78M24CKD	.52	.367	.465
29M15CKD	.58	.408	.516
79M23CKD	.58	.408	.516

Thyristors			
TIC106A	.37	.28	.332
TIC106m	.50	.38	.503
TIC116D	.56	.424	.503
TIC126B	.62	.472	.56

Triacs			
TIC226A	.51	.384	.456
TIC226B	.52	.392	.465
TIC236A	.82	.621	.737
TIC106M	.84	.636	.754
TIC236B	.91	.688	.817

Bridge Rect.			
2A 50v	.38	.288	.342
2A 100V	.42	.32	.38
2A 200v	.47	.352	.418
2A 400v	.59	.448	.532

LEDs			
TIL209	.17	.128	.152
TIL212-1	.21	.156	.186
TIL216-1	.21	.156	.186
TIL220	.16	.118	.14
TIL228	.23	.174	.207
TIL234	.23	.174	.207
TIL232-1	.21	.156	.186

Diodes			
BAX13	.02	.014	.016
1N4001	.045	.034	.04
IN4002	.05	.036	.04
IN4003	.05	.037	.043
IN4004	.055	.039	.046
IN4005	.055	.04	.048
IN4006	.06	.044	.051
IN4007	.06	.047	.055
IN4148	.02	.014	.016
IN4149			

Zeners			
BZY88C series	.07	.047	.055

Capacitors	1+	25+	100+
Electrolytic			
16V 22uF	.075	.066	.052
25v 10uF	.08	.072	.061
47uF	.09	.078	.066
100uF	.14	.124	.104
1000uF	.27	.237	.187
63V 1.5,6.8 2.2,3.3,4.7	.12	.106	.089
10uF,15uF	.12	.107	.09
22uF	.14	.121	.102
47uF	.17	.147	.124
Ceramic 100v			
1;8-47pF	.048	.043	.036
68-82pF	.06	.055	.046
120-680pF	.083	.074	.062
Metallised Film 250V			
.01,.015,.022	.075	.069	.057
.033,.047,.068	.08	.072	.06
.1	.094	.085	.071
.15	.11	.097	.082
.22	.13	.11	.092
.33	.17	.152	.128
.47	.20	.177	.149
.68	.27	.242	.204
2.2	.57	.514	.433
Film Foil 400V			
.001,.0015, .0022	.15	.135	.113
.0033	.16	.138	.116
.014,.022	.17	.152	.128
.033	.19	.169	.142
.047	.22	.195	.164
.1	.26	.235	.198
.15	.34	.307	.259
.22	.43	.389	.328
Tantulum Cap			
.1,.22,.47,.35v 4.7,6.3v	.09	.074	.062
1.2.2,25v 4.7 10v	.10	.085	.072
2.2 35v,4.7 25V	.12	.102	.086
6.8 6v	.09	.076	.064
6.8 35v,10 25v 33 10v, 47 6.3v 100 3v	.15	.133	.112
10 6.3v	.11	.095	.08
10 16v	.14	.119	.10
10 35v	.17	.153	.129
22 6.3v	.12	.106	.089
22 10v	.14	.123	.104
22 16v	.17	.153	.129

Resistors	1+	25+	100+
Carbon Film 5% E12			
¼ watt	.015	.01	.009
½ watt	.02	.014	.012
1 watt	.05	.038	.032
Trim Pots Type 90 single turn open trimmer, horizontal or vert. in E3.			
10R-2M2	.32	.285	.24
Type 94 20 turn ¾ trim pin in E3.			
50R-1MO	.68	.60	.51

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LM318TO66	£ 2,65
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LM320	£ 7,29
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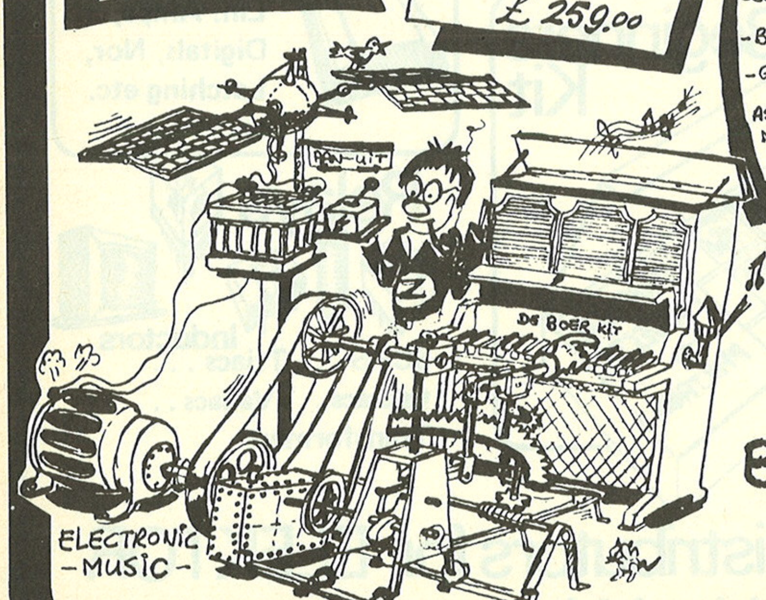

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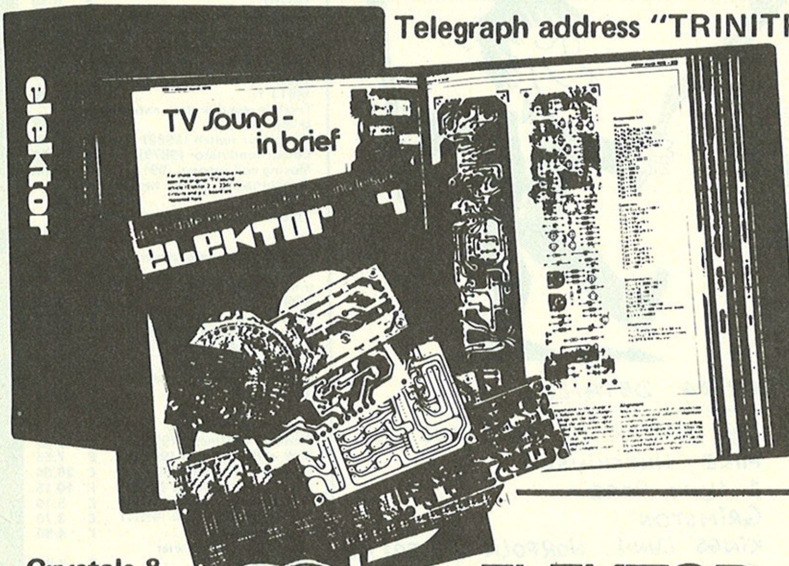

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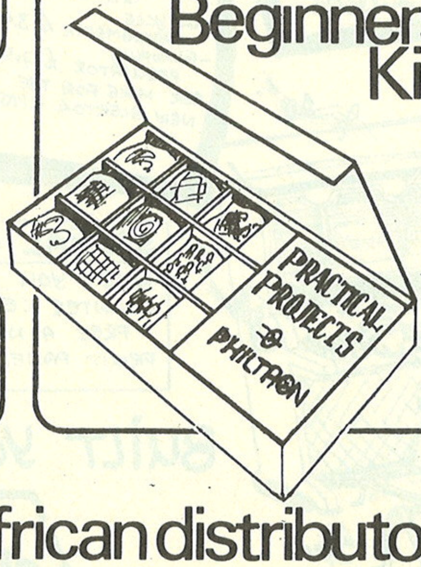

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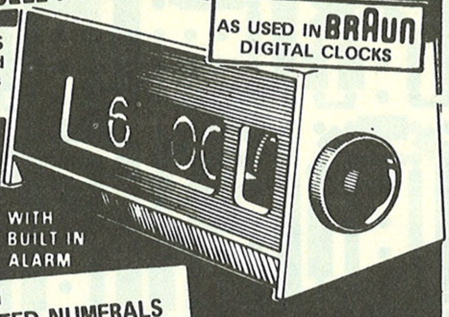

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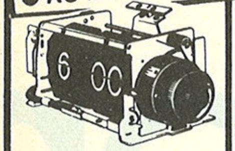

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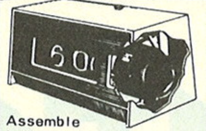

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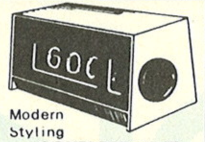

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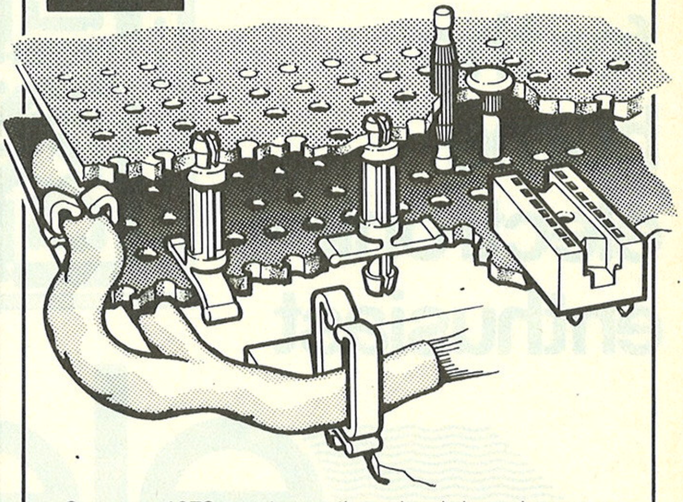

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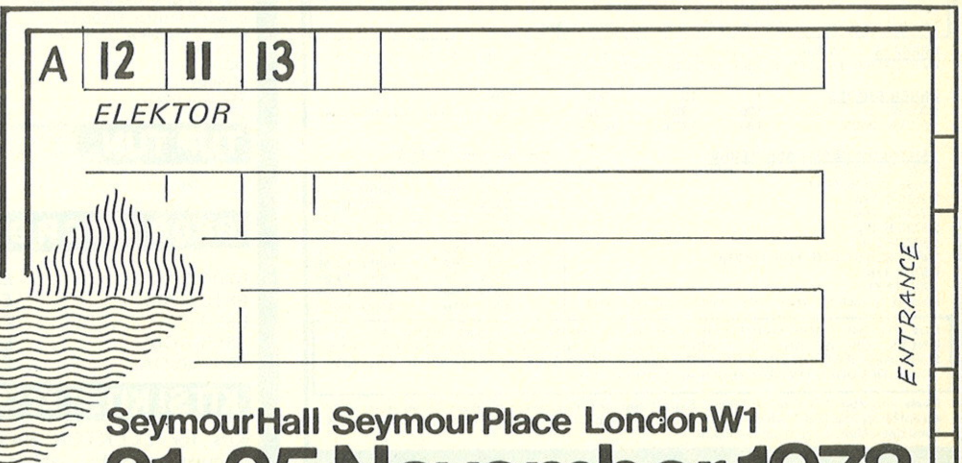
Our editorial staff will be demostrating many projects published in Elektor and extend a warm welcome to our readers who visit the show. We hope to see you there!



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SELEKTOR

Major development in telephone engineering

A fivefold increase in the capacity of existing telephone lines might be possible within five years as a result of a new speech processing system being developed in Britain.

The UK Ministry of Defence says a top military communications expert and a team from the University of Bath's School of Electronic Engineering in Western England has solved a speech transmission problem that has baffled scientists for years.

The result, it is claimed, is a system that transmits speech by wire or radio with greater clarity and efficiency than at present. It will be marketed, it is hoped, at less than a tenth of the cost of existing systems.

Patent applications have already been filed and experts are now predicting that worldwide commercial sales could be worth millions of pounds sterling.

It is not only the world's telephone systems that stand to gain from the development. Others who could benefit, in the long-term, include deep sea divers and the partially deaf. In the case of divers the system could improve the quality of helium-affected speech, while hearing aids could be made more efficient.

Terminal smaller than shoebox

The Ministry of Defence says details of how the new system works are classified. But it is known that it reduces speech patterns with the aid of computers to a small number of basic 'shapes.' It is possible to break down and reconstruct combinations of these shapes like jigsaw puzzles.

The system's terminal will be smaller than a shoebox.

The military communications expert involved, Brigadier Reg King, did some research into speech processing eight years ago but it was not until he joined forces last year with Professor William Gosling, head of Bath University's School of Electronic Engineering, that major progress was made.

Brigadier King said: 'In the end, the answer was so simple that I had trouble in convincing myself that it really worked. I had the system checked on a second computer in case we had overlooked some vital detail, but it came up with the same result'.

Professor Gosling commented: 'There is no doubt whatsoever that this represents a revolutionary concept in communications engineering. The mathematicians have always said that it could not be done. I think it was mainly Brigadier King's ability to tackle the problem obliquely and his dogged military persistence in refusing to accept defeat that enabled him to solve the seemingly insoluble'.

A prototype of the system now being built should be ready for evaluation in some 18 months time. It is said that a fully engineered version could be in general use within the next five years.

(361 S)

New Finds

A new smaller-diameter version of the Ferranti inertial directional surveyor (FINDS), known as the Model 1063, has been developed. The outside diameter of the new tool is $10\,^{5}/_{8}$ inches (270 mm) which will enable it to be used to survey $13\,^{3}/_{8}$ inches casings down to depths of 8,000 ft.

Preliminary trials have indicated that the FINDS 1063 tool can produce survey measurements to an accuracy of 6 inches in all three channels (North, East and vertical) at the maximum depth at which it has been used to date — 4,800 ft. The trials have been conducted in association with Shell Expro in the Brent and Dunlin fields.

The first experimental surveyor designed by Ferranti had a diameter of 17½ inches and was used down to depths of 1,500 ft. very successfully. The significantly smaller diameter of the new 1063 tool has been achieved by repackaging the inertial sensor assembly and its associated electronic units. This will enable oil and gas wells to be surveyed very accurately over a significant proportion of their total depth.

FINDS - principle of operation

FINDS is an adaptation of an inertial sensing unit designed for the precise navigation of aircraft. The unit has been proven in service over many years and is exceedingly robust.

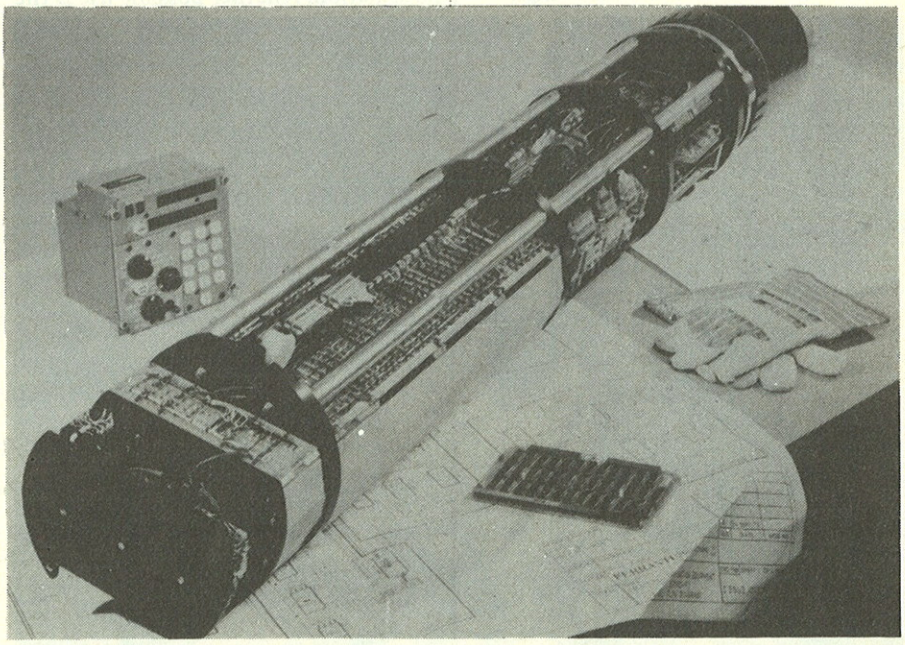
The inertial sensing unit comprises a gyroscopically stabilised platform which is maintained within one minute of arc of a fixed attitude in space regardless of changes in the orientation of the vehicle in which it is being carried. Three precision accelerometers are mounted on the stabilised platform with their axes aligned mutually at right angles to one another. One axis is automatically gyro-compassed to face north. The accelerometers detect accelerations along all three axes and the output signals are integrated twice to derive displacements from the known starting datum. These functions are carried out whilst the tool is in motion and the derived co-ordinates recorded in a semiconductor store every 0.1 second.

On recovery of the tool these results are transferred to a computer store for immediate analysis, the results being produced at specified depth intervals and presented in a chosen format.

Battery powered, the entire system is self-contained and can operate for several hours independently of external services. Survey runs, however, are of short duration since the tool can be lowered at the maximum wireline (or sandline) speed and has been tested in free-fall conditions at 1,500 ft/min. It need only be stopped for ten second fixes every one to two minutes and this transit interval can be increased, if required, at the expense of accuracy.

Ferranti Offshore Systems Ltd.
Ferry Road
Edinburgh
EH5 2XS

(358 S)



SELEKTOR

Telephone with telescribble

People will soon be able to speak and write to each other via the telephone at the same time. Philips Telecommunicatie Nederland has developed a system, called the Scribofoon, comprising an electronic note pad and a visual display unit, which can be used to transmit graphic information via telephone lines. The system can be used either by two people, by several people if they are taking part in a telephone conference, and in mobilophone communications. A number of pilot projects will be set up in the Netherlands next year (1979) to evaluate the system.

Once the Scribofoon has become widely accepted, its cost is expected to be about the same as that of a colour television set. Before that, however, it will cost more because of the small series which will be made.

Philips Telecommunicatie Nederland based the Scribofoon's development on research done at Delft University of Technology where the staff of the Information Transmission Laboratory developed a method of transmitting pictures via radio. The work done by Philips Telecommunicatie Nederland, in co-operation with the Dutch Post Office's Dr. Neher Laboratory, aimed at applying this method to achieve two-way picture transmission via telephone lines and at developing the equipment.

A very small part of the telephone frequency band, the conversation band, is reserved for transmitting the pictures without any unfavourable influence on the telephone conversation. This means that picture and speech can be transmitted simultaneously so that one can talk and write via the telephone at the same time. Thus, a telephone conversation can be clarified with drawings, sketches and maps for example. When one person is writing, the other cannot do so because the facility is blocked.

The Scribofoon consists of a screen and a writing pad. This pad contains printed wiring: vertical wires on top of a plastic layer and horizontal wires underneath it. An electric pulse scans this network of wires. When a pen touches the paper covering the pad it acts as an antenna and signals the moment when the rapidly scanning pulse is maximal, in other words nearest to the pen. The system then knows the pen's position because the time-lag between the start of the pulse and it being seen by the pen is specific for a certain position on the pad. These positions are then transmitted via the telephone line and made visible on the other subscriber's screen. This transmission is made at normal writing speed.

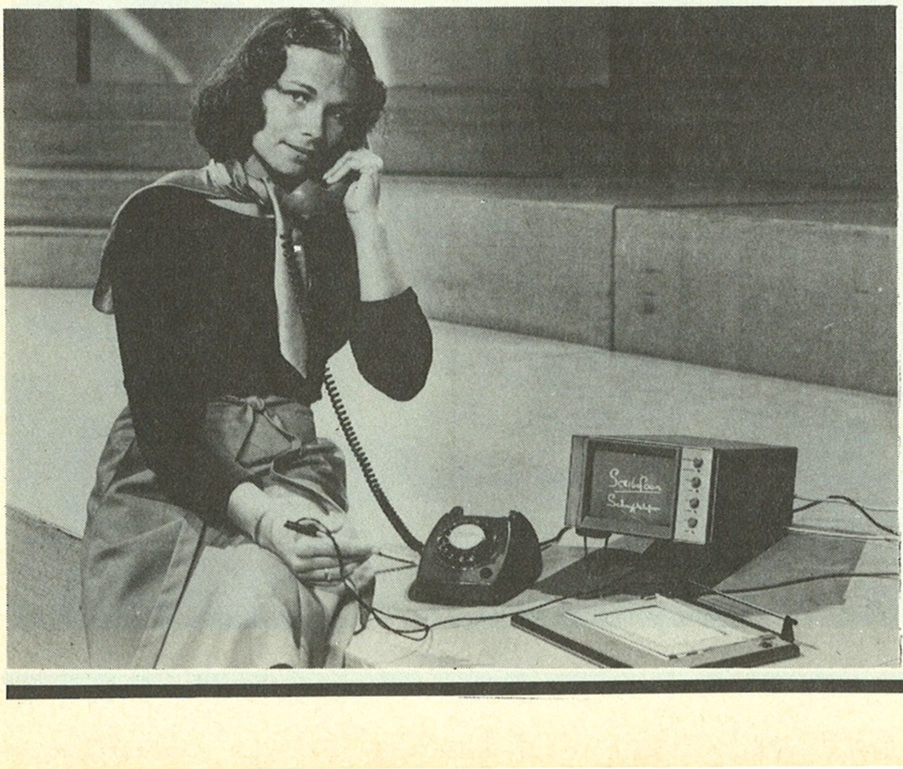
When a group of people are using the system, the graphic information appears on everyone's screen at the same time. Members of the group can propose additions or corrections because an erase facility is a feature of the Scribofoon. The pen can also be used to point out a detail of the picture without this mark being incorporated into the picture. Both the telephone drawing and the spoken conversation can be recorded on a normal cassette recorder for later reproduction. In the Scribofoon's application with mobilophones, bodies such as the police and fire brigade could use the system for quickly transmitting a situation sketch, for example.

International interest has already been shown in the system, also for its possible uses in education. A pre-recorded, language-teaching cassette could be used to pass on spoken and written information. Another possible use is the transmission of cartoons. Pre-recorded audio cassettes could contain the story on one track and the pictures on the other.

Philips Telecommunicatie Nederland's experimental equipment included oscilloscopes for presenting the pictures. However, television screens are used in the current version. In addition, integrated circuits will be applied in future so that the quipment will then be smaller and cheaper. The main cost factor is the filter in the central unit which goes next to the telephone.

Philips Telecommunicatie, Netherlands.

(393 S)



On the trail of interference

The Automobile Equipment Group 1 of Robert Bosch GmbH has recently acquired a new weapon with which to hunt down annoying sources of radio interference. A computer-controlled VHF - UHF test assembly supplied by Rohde & Schwarz will be used for investigating interference suppression in cars, car parts of the company's own production – such as ignition systems, electric motors and generators –, film cameras marketed under the Bauer label and emergency generator units.

The main component of the test assembly, the VHF - UHF Test Receiver ESU 2, measures over the frequency range of 25 to 1000 MHz in compliance with the VDE guidelines 0875 to 0877 and 0879, the CISPR Publications 2, 4 and 12 to 14, and European Community directives. The Basic-programmable desktop computer 4051 from Tektronix presents the test results in graphic and tabular form on its large storage screen. Programmed evaluation of the results by the computer is also provided, as is permanent documentation on the Hard Copy Unit 4631.

This automated test assembly can be used for measurements on useful radio signals as well as on interference, and is suitable for operation in the field, in the laboratory or in a test vehicle. The assembly comprises the VHF - UHF Test Receiver ESU 2, the Frequency Controller EZK and two Code Converters PCW from Rohde & Schwarz, the Graphic Computing System 4051 and Hard Copy Unit 4631 from Tektronix, a digital voltmeter and a frequency counter.

For frequencies from 25 to 1000 MHz the receiver has a voltage measurement range of –10 to +120 dB (μV) and can measure two-port transfer constants from –90 to +40 dB.

(379 S)

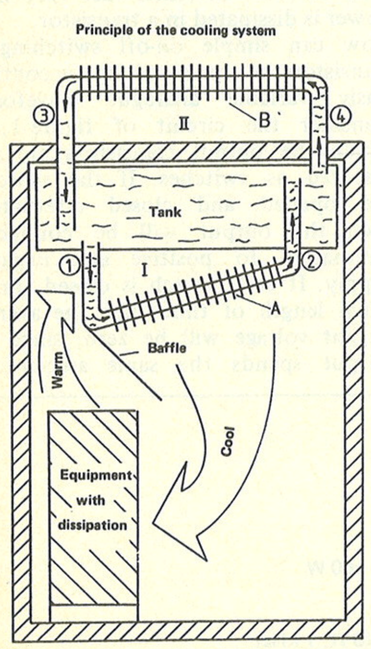
SELEKTOR

Using heat to cool the Sahara

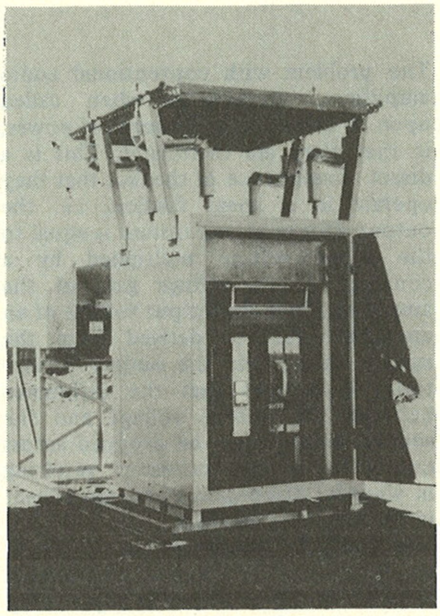
A small communications station in the north African desert is constantly heated up by the dissipation of its radio relay amplifiers. And yet even in the extreme midday heat the temperature inside the insulated shelter is about ten degrees below that outside. The cooling effect is produced without pumps and fans, entirely without the use of energy, by means of an ingenious 'rectifier' system of air and water cycles devised in the Siemens development laboratories. Working roughly on the principle of gravity-circulation hot-water heating, the system extracts heat from the interior during the day, stores it in a water tank and discharges it to the environment during the night. In this way the system acts as a 'refrigerator' during the day.

The cooling system was developed in an effort to protect communications equipment in extreme climates from excessively high temperatures, without additional energy having to be supplied for this purpose. The shelter (1.3 m^3 volume), equipped with heating elements (150 W), fulfilled all expectations the very first time it was tested in the climatic chamber. The equally good results obtained in the test under extreme outdoor conditions encouraged Siemens to extend the tests to larger shelters with a volume of about 20 m^3. The unpowered cooling system is based on the differences in density and weight of liquids caused by different temperatures. It consists of three cycles. The warm air rising from the equipment in the shelter is first guided by a baffle to heat exchanger A where it cools and consequently flows downwards again to the equipment. The second cycle is formed by the water in exchanger A. It heats up, expands and, as a result of its lower specific weight, passes through an ascending pipe to a central tank inside the shelter, while a downpipe with cooler water feeds exchanger A.

Principle of the cooling system



I Inner water cycle
II Outer water cycle
A Heat exchanger, inside
B Heat exchanger, outside
1 Downpipe to A
2 Ascending pipe from A
3 Downpipe from B
4 Ascending pipe to B



Heat exchanger B, which links the tank with the exterior, is warmer during the day, so that no cycle is created. At night, however, as soon as the outside temperature drops below the temperature of the tank, the third and most important cycle is started up: the water from exchanger B cools the contents of the tank — via an ascending pipe and a downpipe again — until the densities have become equal or until the ambient temperature rises above that of the tank again. The reservoir cooled in this way is then used for fully automatic cooling of the interior during the day.

Siemens AG, München, W-Germany.

(395 S)

'Charged' cars are no danger

You occasionally see them: cars dragging a 'tail' of metal braiding and hard rubber behind them, intended to discharge the static charge of the vehicle. The idea comes from the big tanker trucks, which always drag along a metal chain touching the ground. But does this 'discharge band' really serve any useful purpose? Engineers at the Siemens high-voltage laboratory in Berlin investigated to what extent cars are charged while being driven. Friction between the wheels and the road surface is the main cause for the electrical charge. The rubber-tired vehicle is electrically insulated as it rolls on the roadway; it is — from a physical point of view — a capacitor with a capacitance of about 100 pF. When the weather is dry and the insulation resistance of the tires is thus sufficiently high the 'autocapacitor' will be charged to approximately 10,000 V. The energy stored equals about 0.005 Ws. This amount of energy is so small that it can be discharged via the human body without causing any harm whatsoever. If a 'charged' car is touched with the hand, the energy will almost completely discharge in about a microsesond. In a darkened room this discharge could be perceived as very thin blue sparks, but in daylight or with street lighting it remains invisible. The whole effect is thus similar to the static charge experienced when one walks on synthetic carpets: it is a nuisance, but completely harmless.

The electrical voltage between the car body and the road surface can always be measured in terms of tens of thousands of volts even at high speeds since pointed or sharp-edged parts of the car body provide for local discharging and prevent higher voltages from being attained.

It is questionable whether conductive bands can prevent cars from becoming charged. The vehicle can only be charged when both the road and tires are dry — in the rain a good electrical discharge is always available. A dry road surface acts as a high electrical resistance, making it difficult to bring the charge from the car to the ground. For the owner of a passenger car there is really only one piece of advice: since it is impossible to protect oneself against spark discharges resulting from static charging it is better to accept them without a fuss. If one is prepared for the tingling sensation it is easier to take. People are not endangered by the charge on a car — regardless of whether or not one attaches a 'lightning conductor' to the car or not.

Siemens engineers once again advise motorists caught in a thunderstorm to drive to the nearest parking space and remain in the car. Since the vehicle is a closed Faraday cage passengers are best protected against lightning inside the car.

Siemens AG, München, W-Germany.

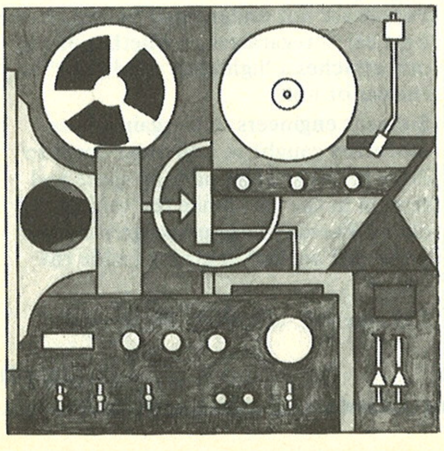
(394 S)

PWM audio amplifiers

Although the concept of the pulse-width modulated or 'Class-D' audio amplifier has been known since the late nineteen-forties, there has been little practical exploitation of the technique apart from a few short-lived designs by Sinclair and Mullard in the nineteen-sixties.

However, recent advances in semiconductor technology, power FETs in particular, have made the class-D amplifier a more feasible proposition, and the PWM concept has been resurrected by some Japanese hi-fi firms.

This article takes a look at the principles of class-D amplifiers and examines the circuit of a commercial design.



The problem with conventional audio amplifiers, particularly when called upon to deliver large amounts of power, is that they are inefficient. This is a direct consequence of the fact that they operate in a linear fashion, i.e. the output voltage at any instant is equal to the input voltage multiplied by a constant – the voltage gain of the amplifier. Since the output voltage of an amplifier must be derived from the supply voltage via the output transistor(s) it follows that the difference between the output voltage and the supply voltage must be dropped across one of the output transistors, resulting in wasteful dissipation of energy as heat in the output transistors.

The output transistors in a linear amplifier can be likened to variable resistors whose resistance is adjusted by the input voltage so that the voltage developed across the amplifier load is always equal to the input voltage multiplied by the voltage gain of the amplifier. To take a simple example, suppose an amplifier is delivering a voltage equal to half supply into a load, R. The effective resistance of the output transistor is thus also R, and the same power is dissipated in both the load and the output transistor, representing an efficiency of only 50%.

The highest efficiency that a conventional class-B amplifier can hope to achieve is obtained when the peak output voltage (neglecting losses due to transistor saturation voltages) is equal to supply voltage, i.e. no voltage is dropped across the output transistors on signal peaks. For a sinewave input signal the efficiency achieved at this level is around 70%. Of course, in a practical situation with a music input the amplifier rarely achieves full output and the average efficiency is much lower.

Clearly the efficiency of a conventional amplifier is limited because the output transistors are used as 'rheostats' to regulate the voltage developed across the load. The only way that this can be avoided is to operate the output transistors as switches. This means that a transistor would either be turned hard on, passing current but with very little voltage developed across it, or cut off, in which case it would have full supply voltage across it but would be passing little current. In either case very little power is dissipated in a transistor.

How can simple on-off switching of transistors be translated into a continuously variable analogue waveform? Consider the circuit of figure 1, in which the output transistors are represented as switches. If the switches are opened and closed alternately, then the output will be connected alternately to positive and negative supply. If each switch is closed for an equal length of time then the average output voltage will be zero, since the output spends the same amount of

Table 1.

Specifications of the TA-N88

Output power: (both channels driven simultaneously)	2 x 160 W
Damping factor:	20 (8 Ω, 1 kHz)
Harmonic distortion:	⩽ 0.5% at ⩽ 2 x 160 W
IM distortion: (60 Hz/7 kHz; 4:1)	⩽ 0.1% at ⩽ 2 x 160 W
Frequency response:	5 . . . 40,000 Hz ± 0.5 dB
Signal-to-noise ratio:	⩾ 110 dB (inputs shorted)
Input sensitivity:	1.4 V RMS into 50 k
Loudspeaker impedance:	8 . . . 16 Ω
Total consumption under full load:	550 W (total efficiency over 58%)

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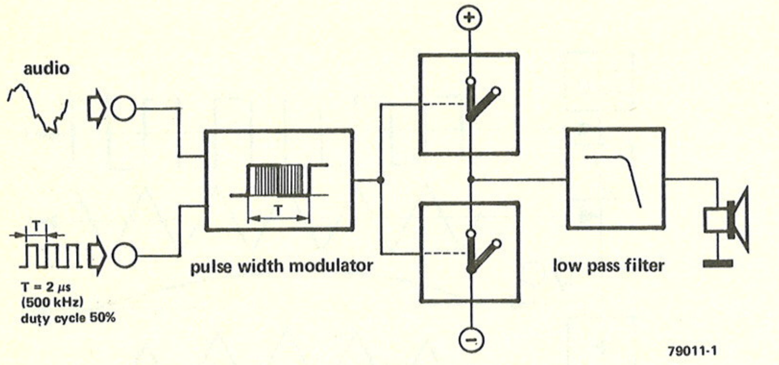

Figure 1. Block diagram of a pulse width modulated amplifier, the basic constituents of which are: the analogue input signal, a symmetrical squarewave, a pulse width modulator, a switched output stage and a passive lowpass filter.

Figure 2. This figure illustrates how the duty-cycle of the squarewave pulse train is varied in accordance with the amplitude of the analogue input signal. The diagram should be 'read' from top to bottom, one line at a time. The conversion from amplitude to time (i.e. duration of the pulse) can be clearly seen.

time at the positive potential as it does at the negative potential.

If the upper switch is closed for a longer time than the lower switch, i.e. the duty-cycle is greater than 50% then the average output voltage will no longer be zero but will be positive. Conversely, if the duty-cycle is less than 50% then the average output voltage will be negative. Since one output transistor is always turned hard on and the other is turned off, there is little power dissipated in the output transistors.

These are the essential principles of a PWM amplifier. The output transistors switch the load alternately to the positive and negative supply at a rate much greater than the highest audio frequency. The audio input signal is used to control the duty-cycle of the switching waveform such that the average output voltage is proportional to the audio input voltage. This principle is illustrated in figure 2, where 23 consecutive cycles of the switching waveform are shown underneath one another. The duty-cycle modulation for a sinewave input is clearly visible.

To retrieve the audio signal free from the switching waveform, all that is required is to interpose a lowpass filter between the output and the load. To minimise losses in the filter it must, of course be a passive LC filter consisting of low-loss inductors and capacitors.

Class-D building blocks

So far only two sections of a PWM amplifier, the switched output stage and the output lowpass filter, have been considered. The most important section of a PWM amplifier is the pulse-width modulator, which converts the audio input signal into a variable duty-cycle squarewave. This is not such a complicated procedure as it might at first appear, and the 'building blocks' of a pulse-width modulator are quite standard circuits which should be familiar to many readers. A more detailed block diagram of a PWM amplifier is given in figure 3.

The first step is to generate a squarewave with a 50% duty-cycle at the

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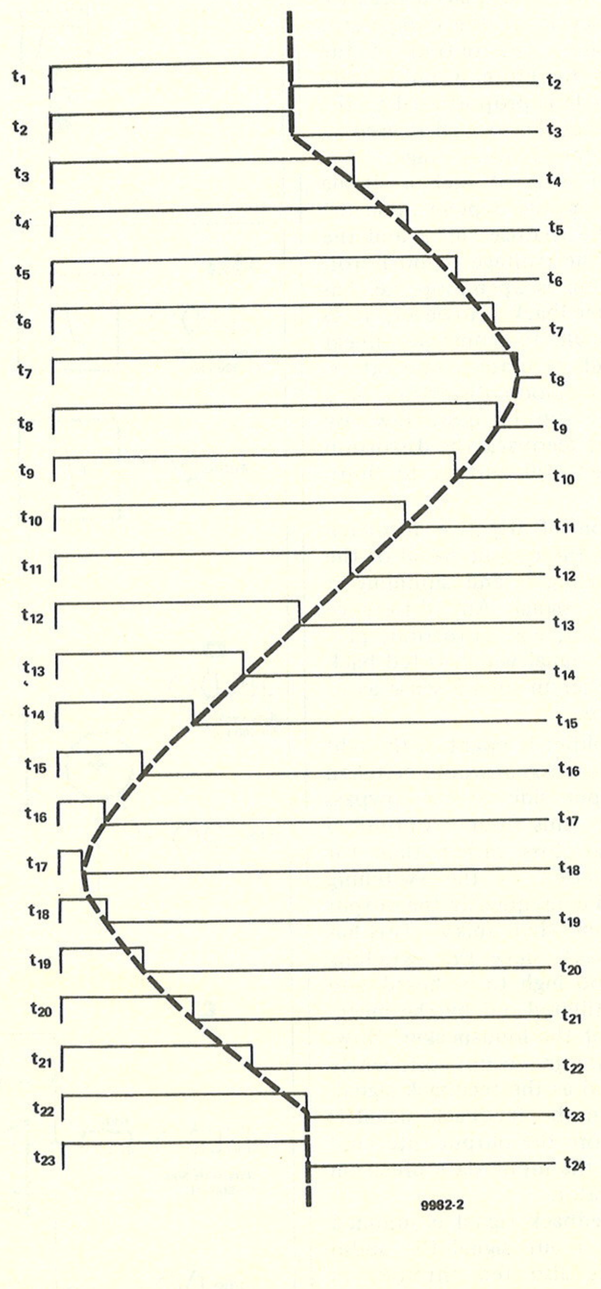


switching frequency. This is then fed through an integrator to produce a triangular waveform of the same frequency.

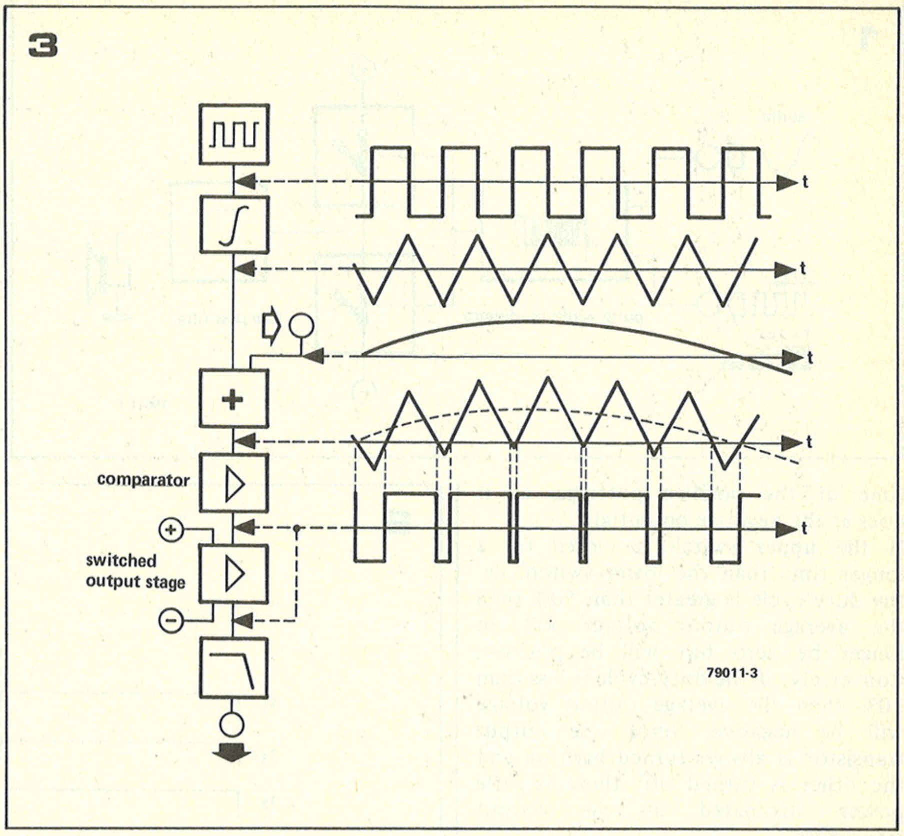
The triangle waveform is summed with the audio waveform and the resultant signal is fed to a zero-crossing detector, i.e. an analogue voltage comparator which has one input tied to zero volts. If the audio signal level is zero then the signal fed to the comparator is simply the triangle waveform whose zero-crossing points occur precisely in the centre of the waveform, so the output of the comparator is a squarewave with a 50% duty-cycle. If the audio waveform is going positive then the triangle waveform is also displaced positive so that it spends more time above zero than it does below. The duty-cycle of the comparator output therefore increases. Conversely, when the audio waveform is swinging negative the triangle waveform is displaced negative and the duty-cycle of the comparator output decreases. The output of the comparator is therefore a pulse train whose duty-cycle is proportional to the audio signal level. This signal is used to control the switched output stage.

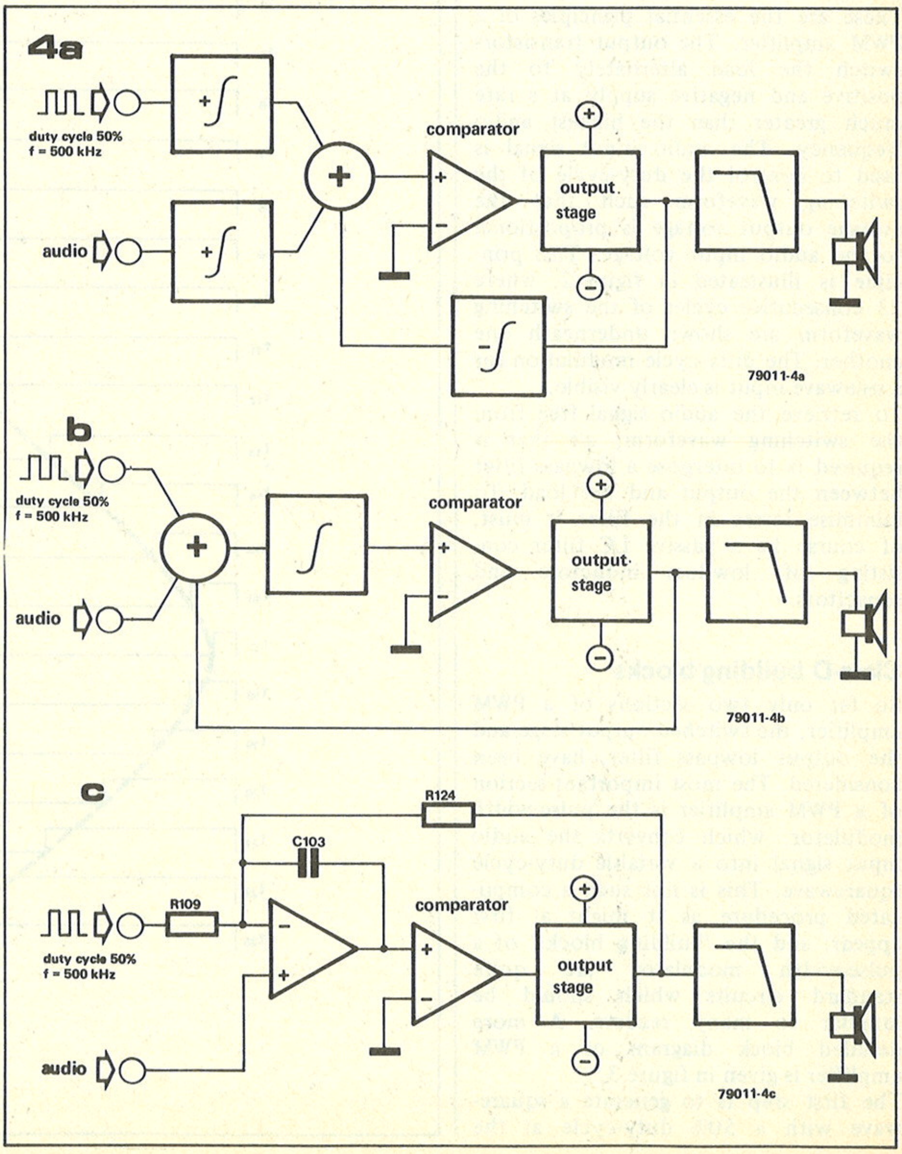
The distortion level of such a simple PWM amplifier would depend upon the linearity of the triangle signal and the accuracy of the voltage comparator, since the system is open-loop, i.e. has no negative feedback. However, it is not too difficult to construct linear integrators and accurate comparators, so that the open-loop distortion of a PWM amplifier can be quite low. By adding negative feedback the distortion can be reduced still further to 'hi-fi' levels.

The application of negative feedback involves taking the output signal of the amplifier, inverting it and summing it with the input signal. Any difference between the two, e.g. distortion, produces an error signal which is fed back into the amplifier in such a sense as to correct the error.

In a PWM amplifier it might be thought that the feedback signal would be taken from the output side of the lowpass filter. However, this filter is optimised for low energy loss rather than for maximum rejection of the switching frequency, and consequently the output waveform is somewhat 'spiky'. This has no audible effect, since the switching frequency is too high to be heard, and in any case is filtered out by the mechanical inertia of the loudspeaker. However, the output signal is not sufficiently clean to be used as the feedback signal. For this reason the feedback signal is picked off before the output filter and is fed back to the input via a precision inverting integrator.

So that the feedback signal is summed with a similar input signal the audio input signal is also fed through an identical integrator. This arrangement is shown in figure 4a. It will be seen that three integrators are involved, one for





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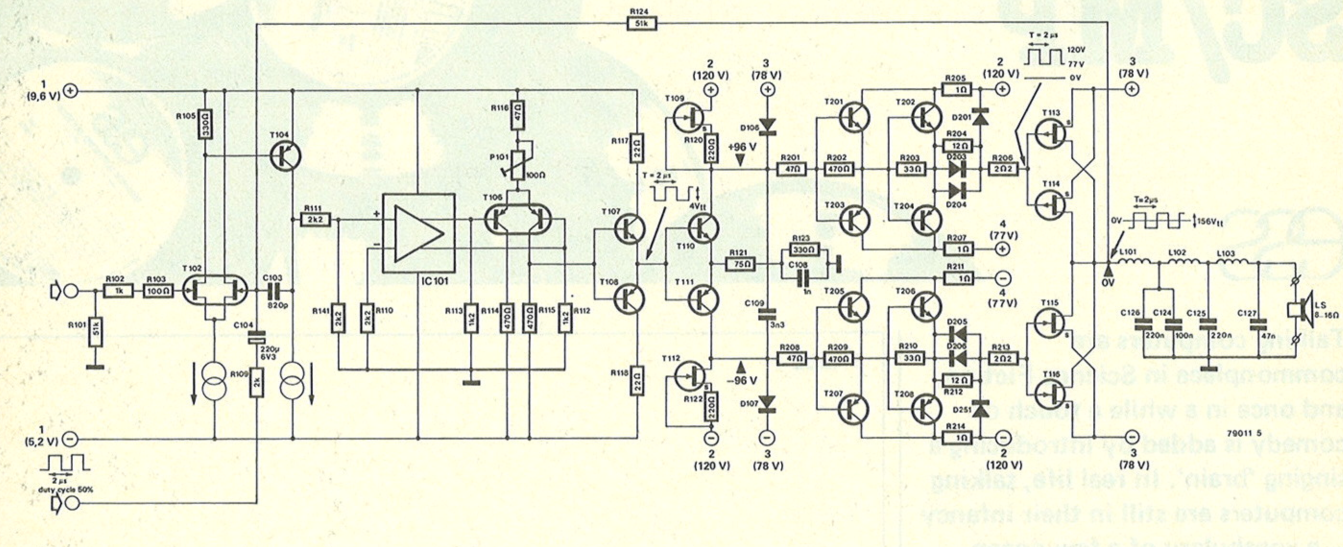


the feedback signal, one for the input signal, and a third to convert the squarewave signal into a triangle waveform. A more economical system is to use a single integrator placed after the summing point, as shown in figure 4b. If this circuit is elaborated slightly, as shown in figure 4c, we in fact obtain the block diagram of a currently available commercial PWM amplifier – the TA-N88 from Sony.

From theory to practice

The basic circuit diagram of the TA-N88 is shown in figure 5. The circuit shown does not include the power supply, which is also pulsed (at 20 kHz), or the current limiting (if excessively high currents appear on the +3 or –3 V supply lines, the input voltage at the junction of R102/R103 is shorted to ground), thermal overload and DC protection circuits (in the latter case this is simply a relay in the loudspeaker lead). Furthermore, the 500 kHz oscillator and buffer stage are also omitted.

The integrator of figure 4c is formed by differential amplifier T102 (this is a dual transistor which determines the DC offset at the output of the amplifier) plus T104; both transistors are connected as a constant current source. The squarewave output from the oscillator is introduced via R109; C103 is the integrator capacitor.

The comparator is formed by four differential amplifiers connected in cascade. Three of these are contained in IC101, whilst the fourth is provided by the dual transistor T106. The comparator output is buffered by the complementary emitter follower T107/T108.

Figure 3. Pulse diagram illustrating the operation of the pulse width modulator.

Figure 4. By using feedback around the switched output stage it is possible to reduce the distortion of the amplifier to levels acceptable for hi-fi applications.

Figure 5. Simplified circuit diagram of the Sony TA-N88 PWM amplifier.

The switching for the output stage is realised as follows: the collector currents of the complementary pair T110/T111 are held constant by T109 and T112 respectively. This means that the cascaded complementary emitter followers (T201 through T204 and T205 through T208), which control the V-FET output transistors T113, T114 and T115, T116, are themselves current controlled.

To ensure fast switching of the output transistors, the drivers must be capable of supplying a generous amount of current to charge and discharge the input capacitance of the FETs. This explains the large number of transistors used in the output stage.

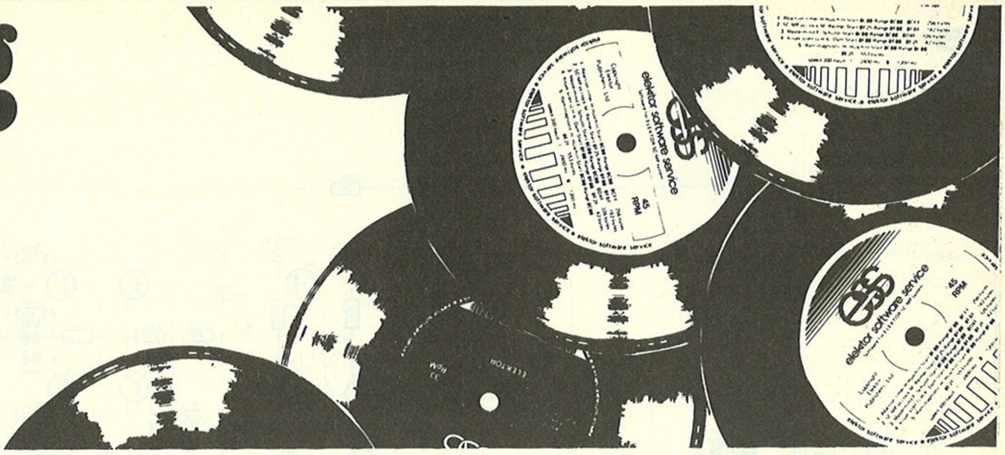
L101 . . . L103 and C124 . . . C127 form the lowpass filter between the output transistors and load (i.e. the loudspeaker). Variations in the impedance of the loudspeaker have little effect upon the operation of the filter.

In conclusion

Cynics may be inclined to view the PWM amplifier as yet another spurious 'innovation' sold by the big hi-fi companies to an all too gullible public, eager to latch onto the latest gimmick or status symbol. However such a view cannot be justified, for there is no doubt that the inherent efficiency of PWM amplifiers makes them ideally suited to today's high output power applications. Not only are class-D amplifiers extremely efficient, but, since the output transistors are not being operated in the linear mode, there is no possibility of distortion being introduced as a result of inherent nonlinearities in the transfer characteristic of the devices.

More significantly, the TA-N88 may be pointing the way to the future evolution of hi-fi equipment. The audio manufacturers are increasingly devoting their attention to digital methods of signal processing, and the PWM amplifier could prove to be a transitional step between conventional analogue systems and a completely digitised audio chain, at the end of which the analogue music signal is recovered by nothing more than a couple of coils and capacitors! ◼

singing SC/MP



Talking computers are commonplace in Science Fiction, and once in a while a touch of comedy is added by introducing a singing 'brain'. In real life, talking computers are still in their infancy — a vocabulary of a few dozen words places them in the 'skilled' category.

Funnily enough, it's much easier to make an 'electronic brain' hum a tune! Even the relatively slow and dull-witted microprocessor can reproduce melodies with a high degree of accuracy. This is demonstrated in the SC/MP program described here. With Christmas in the air, a well-known tune was chosen: 'Silent Night'.

Programs for several other well-known tunes are also included on an ESS record. For interested readers, who are not (yet) the proud owners of a SC/MP system, the μP's rendition of these tunes is recorded 'live' on the B-side of the same disc.

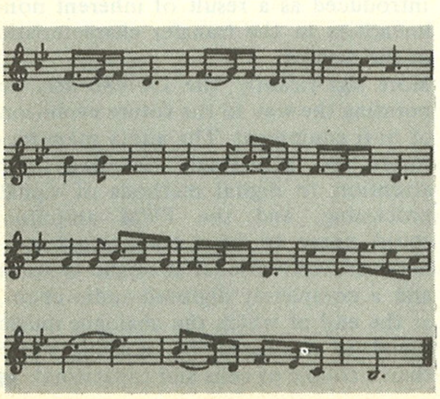


TABLE 1

```
0C00   $ 1  00     HALT               TAB 1  0C53   5A   TAB 2  0C81   C4  03
0C01        C401   LDI X'01                         49                 DC  01
0C03        C84B   ST COUNT 1                       5A                 C4  02
0C05        C84A   ST COUNT 2                       78                 C4  05
0C07        C453   LDI X'53                         5A                 C4  03
0C09        31     XPAL 1                           49                 DC  01
0C0A        C40C   LDI X'0C                         5A                 C4  02
0C0C        35     XPAH 1                           78                 C4  05
0C0D        C481   LDI X'81                         25                 EB  05
0C0F        32     XPAL 2                           25                 C4  03
0C10        C40C   LDI X'0C                         39                 D6  07
0C12        36     XPAH 2                           32                 83  08
0C13        C42F   LDI X'2F                         32                 57  06
0C15        C83B   ST COUNT 3                       5A                 EB  05
0C17   $ 3  C418   LDI X'18                         49                 DC  04
0C19        8F00   DLY X'00                         49                 DC  02
0C1B   $ 2  C402   LDI X'02                         32                 9D  05
0C1D        07     CAS                              39                 F7  01
0C1E        C400   LDI X'00                         49                 DC  02
0C20        8F00   DLY X'00                         5A                 C4  03
0C22        C400   LDI X'00                         49                 DC  01
0C24        07     CAS                              5A                 C4  02
0C25        C400   LDI X'00                         78                 C4  05
0C27        8F00   DLY X'00                         49                 DC  04
0C29        B825   DLD COUNT 1                      49                 DC  02
0C2B        9CEA   JNZ $ 3                          32                 9D  05
0C3D        C024   LD COUNT 1'                      39                 F7  01
0C2F        C81F   ST COUNT 1                       49                 DC  02
0C31        B81E   DLD COUNT 2                      5A                 C4  03
0C33        9CE6   JNZ $ 2                          49                 DC  01
0C35        08     NOP                              5A                 C4  02
0C36        B81A   DLD COUNT 3                      78                 C4  05
0C38        98C6   JZ $ 1                           25                 EB  05
0C3A        C501   LD@ 1 (1)                        25                 C4  03
0C3C        C8E9   ST DELAY                         14                 83  08
0C3E        02     CCL                              25                 93  02
0C3F        F432   ADI X'32                         39                 F7  02
0C41        C8DD   ST DELAY                         32                 9D  0A
0C43        C601   LD@ 1 (2)                        19                 F7  08
0C45        C809   ST COUNT 1                       32                 9D  05
0C47        C80A   ST COUNT 1'                      5A                 C4  01
0C49        C601   LD@ 1 (2)                        78                 6E  03
0C4B        C804   ST COUNT 2                       5A                 C4  03
0C4D        90CC   JMP $ 1                          6D                 AF  01
0C4F        00     4 counter bytes                  8F                 93  02
0C50        00                                      A9                 6D  0C
0C51        00
0C52        00
```

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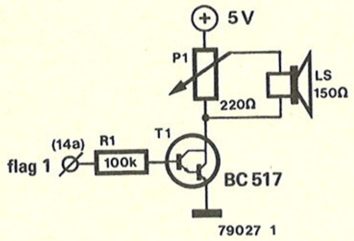

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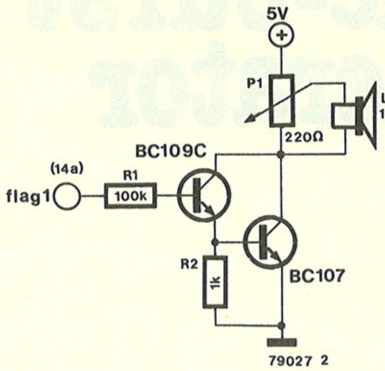

TABLE 2

Note	hex code	frequency
A#	C7	466
B	B8	494
C	A9	523
C#	9C	554
D	8F	587
D#	83	622
E	78	659
F	6D	698
F#	63	740
G	5A	784
G#	51	831
A	49	880
A#	41	932
B	39	988
C	32	1047
C#	2B	1109
D	25	1175
D#	1F	1245
E	19	1319
F	14	1397
F#	0F	1480
G	0A	1568
G#	06	1661
A	02	1760

Figure 1. Only three components are required for a 'loudspeaker interface'.

Figure 2. In case of availability problems, the BC 517 can, of course, be replaced by a standard Darlington configuration.

Table 1. Complete program listing for 'Silent Night'.

Table 2. Using the information given in this Table, it is a fairly easy matter to program the SC/MP for other melodies.

The SC/MP can, of course, sing quite happily to itself. However, if the performance is intended for the benefit of a human audience, a loudspeaker will be required. In computer jargon: a 'loudspeaker interface'. A suitable circuit was described in the recent 'Summer circuits' issue (July/August 1978, circuit no. 12, 'software Kojak siren'). It consists of a Darlington-transistor amplifier and a loudspeaker, connected to a 'Flag' output of the SC/MP (figure 1; an alternative circuit is given in figure 2). If the Flag is set and reset rapidly, a tone is produced; the more rapidly the Flag changes state, the higher the output frequency.

A melody consists of a succession of 'tones' with different frequencies. To make the SC/MP 'sing', it must be programmed to set and reset one of its Flags at a frequency that is determined by a list of numbers somewhere in its memory. Furthermore it must be told, by means of a second list of numbers, how long each note should last. In other words, a program is required that will combine two lists of numbers (one for tone pitch and one for tone duration) to produce a melody. A suitable program is given in Table 1.

The output frequency generated at any given moment is determined by a hexadecimal number XX as follows:

$$f = \frac{10^6}{556 + 8(XX)_{16}} \text{ Hz},$$

where XX is limited to the range $0 \leqslant XX \leqslant CD$ (hexadecimal!).

This limits the SC/MP's singing to two octaves, as shown in Table 2. To avoid the need for combersome calculations, this Table lists the possible notes, the corresponding hexadecimal numbers and the output frequencies. With this information, it is a relatively simple matter to draw up the first list (giving the frequencies of the consecutive notes) for any given melody.

As stated earlier, the duration of each note is determined by a number in a second list. In this program, the tone duration is entered as the number of periods the note is to last. Since this can lead to fairly large numbers, two bytes are reserved for each note, the total number being the *product* of the two numbers involved.

To give an example, assume that the tone required is the low D and that it is to last for 1/4 second. From Table 2, the low D corresponds to 8F and its frequency is 587 Hz. For it to last 1/4 second, 147 periods are required. In hexadecimal: $(93)_{16}$ periods. This is entered in the second list as 93 01 (or 01 93), corresponding to $(93)_{16} \times (1)_{16}$. Finally, the SC/MP has to be told the length of the tune, i.e. the number of notes. Or, to be more precise, the number of notes plus one. This value is entered in address 0C14.

In the program, TAB 1 (starting at position 0C53) is the list of notes required, and TAB 2 is the list of tone durations. The start address of the latter list is stored in 0C0E (lower address byte) and 0C11 (higher address byte).

As an example, the complete program listing for 'Silent Night' is given in Table 1. It is entered from address 0C00; this is also the start address. The program is started by operating the halt/reset key.

If other melodies are to be produced, the lists of numbers under TAB 1 and TAB 2 must be modified accordingly. Furthermore, as mentioned earlier, the start address of TAB 2 must be entered in positions 0C0E and 0C11, and the number of notes plus one is stored in 0C14.

The program described here is included, with 5 other well-known Christmas melodies and 'Mary had a little lamb', on the Elektor Software Service record ESS 002. The B-side of the same recording contains the SC/MP's 'real-time' rendition of the same tunes. ◼

Litt: Experimenting with the SC/MP, Nov. 1977 . . . April 1978;
Software Kojak siren, July/August 1978.

tone-burst generator

A (repetitive) tone-burst signal is an extremely useful aid for testing audio equipment. Basically, this type of test signal is obtained by switching the output of a sine-wave oscillator on and off at regular intervals. The generator described in this article utilises a novel design approach that simplifies the circuit considerably and only involves one minor reduction of the capabilities.

The sinewave is the most commonly used test signal. It is simple to analyse (both 'on sight' and mathematically) so that any distortion can usually be recognised quickly. Its very simplicity, however, is also its main disadvantage: it has very little in common with the signals that an audio system is normally expected to handle: music and speech.

Audio signals are extremely 'dynamic': transients and other more-or-less rapid changes in level are actually the most important information in a speech signal. In order to test a system which is intended to handle this type of material, it seems reasonable to look for a 'dynamic' test signal. There is no way to measure 'transient response' with a signal that is as obstinately steady-state as DC. And that, regrettably, applies to sinewaves.

What about squarewaves? A good second in the list of commonly used test signals. It is definitely better than the sinewave when it comes to pointing out poor transient response. However, it is definitely inferior on several other counts. Just think: a digital NAND gate will pass a squarewave beautifully – but a NAND gate makes a very poor audio amplifier indeed . . .

A tone-burst signal can be considered as a combination of sinewave plus squarewave. It has the advantages of both: it is steady-state for a while, then suddenly changes to a new 'steady state' and so on. A typical tone-burst signal is shown in figure 1. It consists of one or more sinewaves, then a gap (one or more sinewaves in length), then again one or more sinewaves and so on. That it is in some ways similar to a sinewave is obvious; the similarity with a squarewave is perhaps less apparent, until one realises that it is basically equivalent to the output from a sinewave generator that is being turned on and off by a squarewave generator of lower frequency.

All very well, but how does one obtain a 'tone-burst' signal? Apparently, a squarewave generator must 'gate' the output from a sinewave generator. One way of achieving this is shown in figure 2. The sinewave is fed to an electronic switch. As the switch is opened and closed, a succession of sinewave 'bursts' will appear at the output. Control of the switch is rather complicated (more than this simplified block diagram suggests!). The sinewave is fed to a zero-crossing detector; the output from the latter is used as 'clock' signal for two programmable counters. Only one of these counters is 'active' at any given moment – the other is held in the 'reset' position by a flip-flop. When the selected maximum count of the 'active' counter is reached, the flip-flop is triggered. The first counter is then reset and the other counter is enabled. Since the output of the flip-flop also drives the electronic switch, the final result is a number of sinewave periods determined by one counter, followed by a 'dead

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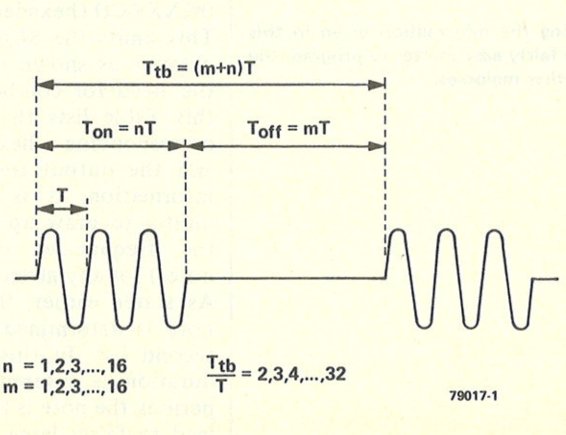

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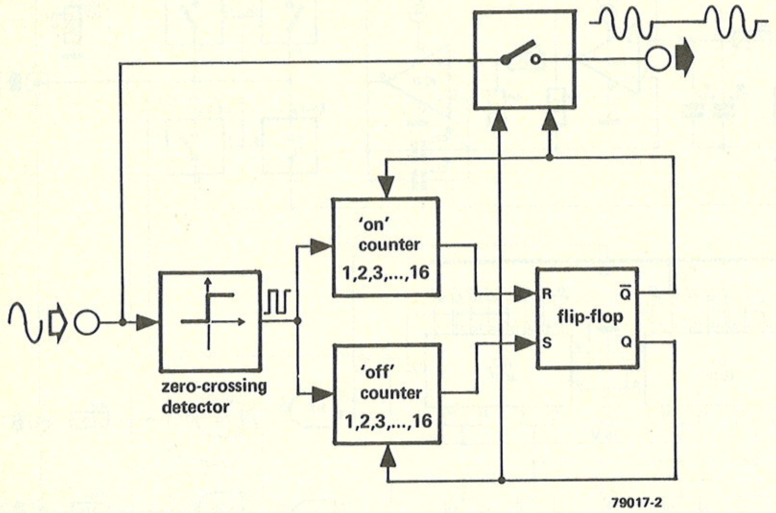

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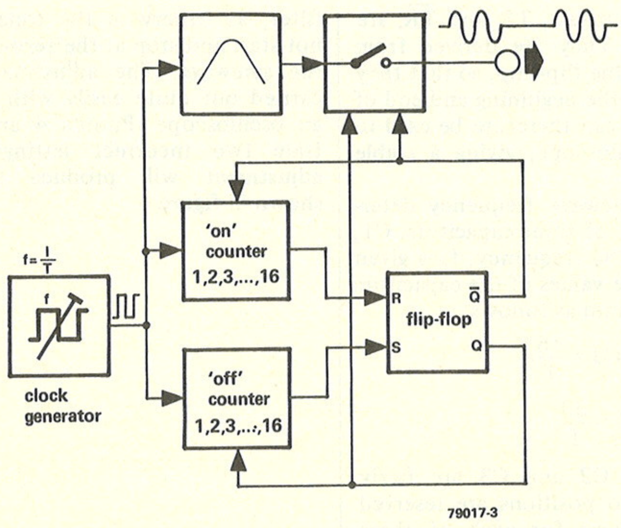

Figure 1. A tone-burst is basically equivalent to a sinewave that is switched on and off at regular intervals. Both the length of the burst and the period between bursts are a whole multiple of the sinewave period.

Figure 2. Block diagram of a conventional tone-burst generator.

Figure 3. Block diagram of a novel alternative.

zone' (no output) determined by the second counter.

A fool-proof system, one would think. However, there is at least one weak link in the chain: the zero-crossing detector. If the output tone-bursts are to start and stop in the zero-crossings of the sinewave, an accurate zero-crossing detector is required – not to mention zero phase-shift throughout the complete chain from detector through counters and flip-flop to switch.

These problems can be solved – witness the proliferation of commercial tone-burst generators that work according to this principle. However, why bother? A different approach obviates the whole problem. The results are certainly good enough for the home constructor – for that matter, they are good enough for professional use. The only problem is that they make for less sweeping advertisements . . .

Why not?

The block diagram of a different approach is shown in figure 3. At first sight, it is very similar to the diagram shown in figure 2. However, there is one major difference: the clock pulses for the counters are not derived from the sinewave. The reverse is true: a selective filter is used to derive the output sinewave from the clock pulses. And it is easier to design – and, more importantly, build – a good selective filter than it is to obtain a good zero-crossing detector.

Any experienced designer who is conversant with the law of cussedness should, by now, be looking for the 'bug'. It's there all right. If the tone-burst is to be turned on and off at the correct moment – during the zero-crossings – the edges of the clock pulses must still correspond with those zero-crossings. Clock pulses and sinewave must be in phase. This implies that the centre frequency of the filter must coincide with the clock frequency, and a fixed centre frequency therefore leads to a fixed clock frequency. Tone-bursts with 'swept' sinewave frequency are no longer possible. So what . . . who needs 'em, anyway?

The circuit

The complete circuit of the tone-burst generator is shown in figure 4. The burst length can be set, by means of S1, at anything between 1 and 16 complete sinewave periods. The interval between bursts is selected in the same way by S2. The clock generator, N1/N2, is a fairly standard circuit. Its output is not particularly 'clean', but suitable processing by the other four inverters in the same package (N3 . . . N6) produces a good squarewave. As illustrated in the block diagram (figure 3), this signal is fed to two counters, one of which (IC1/IC2) determines the length of the burst while the other (IC3/IC4) fixes the interval between bursts. One output of each counter is selected by S1 and S2, respectively, and used to set and reset the flip-flop (N9/N10). The Q and $\overline{Q}$ outputs of the flip-flop are fed back to the counters in such a way that when the count selected by S1 is reached, toggling the flip-flop, the corresponding counter is reset and the other is enabled. In this way, the two counters are used alternately.

The flip-flop outputs are also used to operate the electronic switches S1 . . . S4. When S1 and S2 are closed, the sinewave appears at the output; opening S1 and S2 and closing S3 and S4 blocks the sinewave and passes a DC level, corresponding to the zero level of the sinewave, instead.

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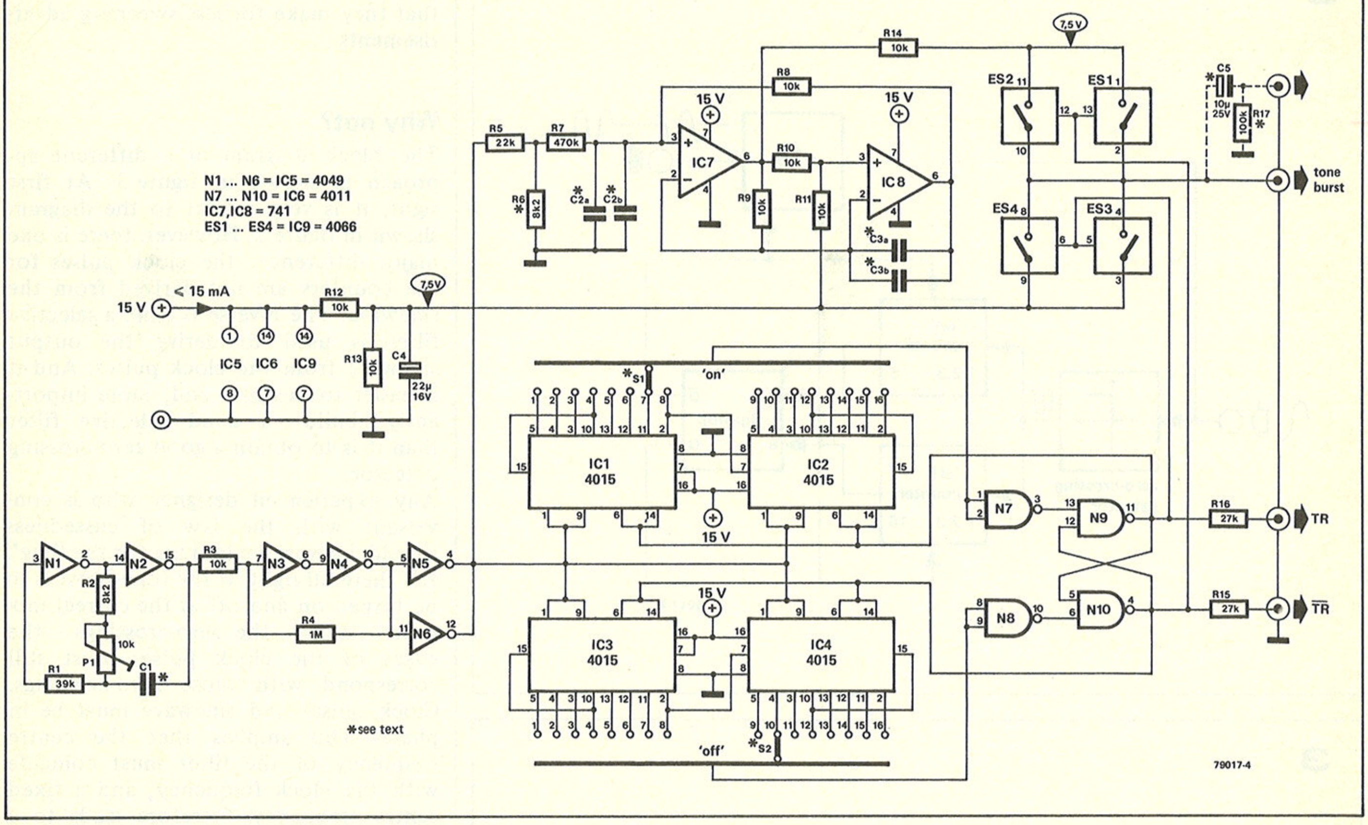


The sinewave is derived from the clock pulses, as described earlier. The clock pulses are passed through a selective filter (IC7/IC8); the centre frequency of this filter, which corresponds to the clock frequency, is also equal to the sinewave frequency of the tone-burst. If a different tone-burst frequency is required, the clock frequency must be altered by choosing a different value for C1, and the centre frequency of the selective filter must be modified by altering the values of C2a/b and C3a/b.

Construction and calibration

A suitable printed circuit board design is shown in figure 5. Fairly standard components are used throughout, with the possible exception of the switches S1 and S2. Several alternatives are possible at this point, depending on availability and cost: 16 single-pole single-throw switches; a 24-way switch (more common than 16-way); a 12-way switch (four outputs of each counter are left unused); two or more switches in cascade; or even hard-wired internal programming of one useful combination (four periods on, say, and eight periods off).

The amplitude of the sine-wave bursts is approximately 8 V peak-to-peak. A 7.5 V DC component is also present in the output signal - corresponding, of course, to the 'zero' level between bursts. This DC component can be blocked by adding C5 and R17, as shown in dotted lines in the circuit diagram. The amplitude of the output sinewave can be modified by altering the value of R6.

Two 'trigger' outputs, TR and $\overline{TR}$, are also provided. They are derived from the outputs of the flip-flop, so that they change state at the beginning and end of each burst and can therefore be used to trigger an oscilloscope, giving a stable display.

The desired sinewave frequency determines the value of three capacitors: C1, C2 and C3. If the frequency, f, is given in kHz then the values of the capacitors in nF can be found as follows:

$$C2 = C3 = \frac{16}{f};$$

$$C1 = \frac{33}{f}.$$

The values of C2 and C3 are fairly critical, and two positions are reserved on the p.c. board for each of these capacitors so that the desired value can be approximated fairly accurately by connecting two capacitors in parallel. For instance, if an exact 1 kHz sinewave is desired, C2 and C3 would have to be 16 nF; this can be obtained by connecting a 15 n and a 1 n capacitor in parallel. The value of C1 is not so critical, since the frequency of the clock generator can be set correctly by means of P1.

The highest frequency obtainable is 20 kHz.

The current consumption of the circuit is quite low: 12 . . . 15 mA.

The calibration procedure is extremely simple – only one potentiometer (P1) requires attention. The idea is that the clock frequency must coincide exactly with the centre frequency of the active filter, as otherwise the toneburst will not start and stop at the zero-crossing of the sinewave. The adjustment can be carried out quite easily with the aid of an oscilloscope. Photos 4 and 5 illustrate two incorrect settings; correct adjustment will produce the result shown in figure 6. ◼

Figure 4. Complete circuit for a tone-burst generator that is more suitable for home construction.

Figure 5. Printed circuit board and component layout for the tone-burst generator (EPS 79017).

Photo 1. Tone burst, 1 sinewave period with a 16-period gap.

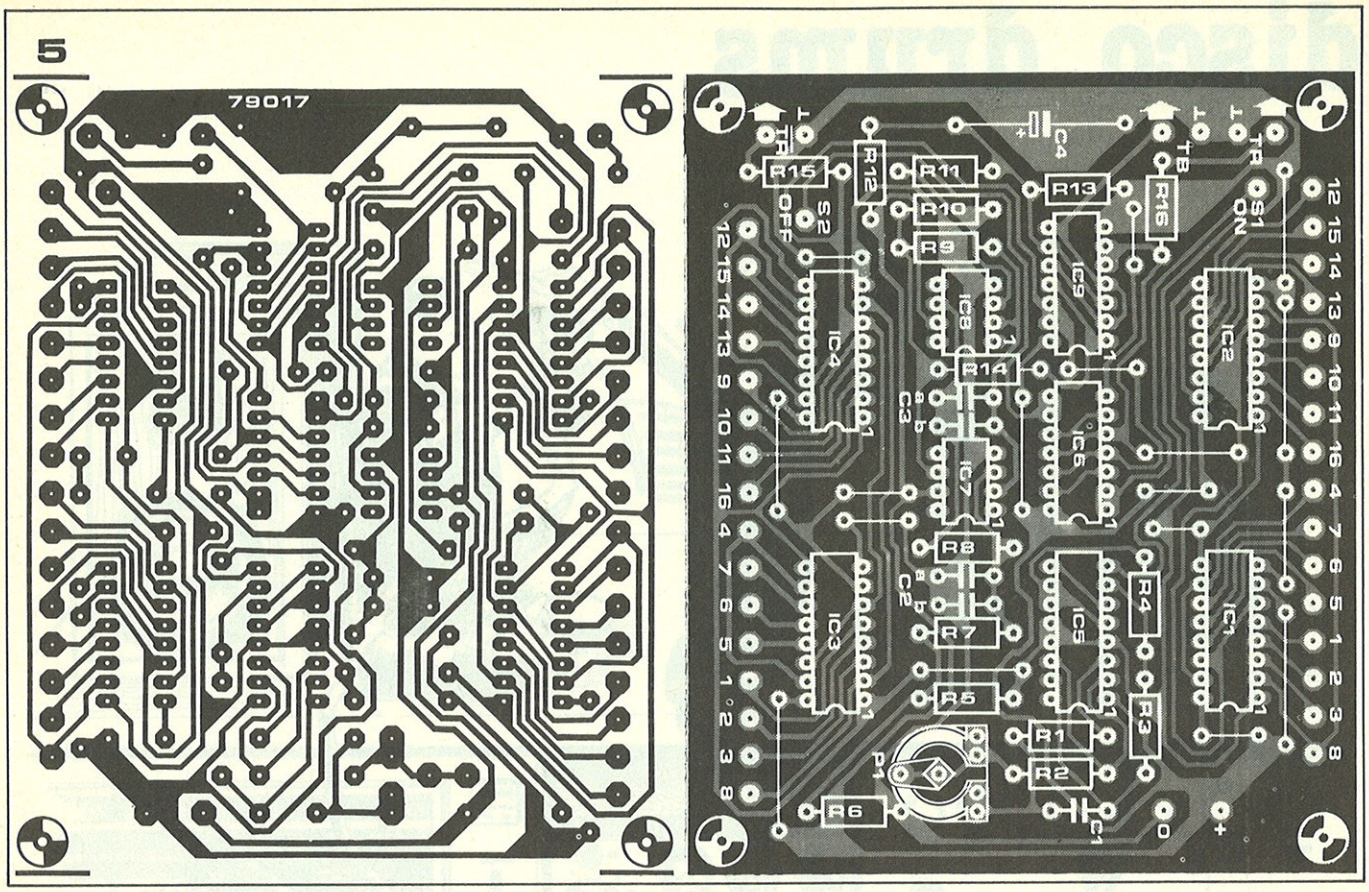
Photo 2. Tone burst, 16 sinewave periods with a 1-period gap.

Photo 3. Tone burst, 16 sinewave periods with a 16-period gap.

Photos 4 and 5. Clock signal and tone-burst with P1 incorrectly adjusted: the burst does not start and stop in the zero-crossings of the sinewave.

Photo 6. Tone-burst output after P1 has been accurately adjusted.

5



Parts list

Resistors:
R1 = 39 k
R2,R6* = 8k2
R3,R8 . . . R14 = 10 k
R4 = 1 M
R5 = 22 k
R7 = 470 k
R15,R16 = 27 k
R17* = 100 k
P1 = 10 k preset

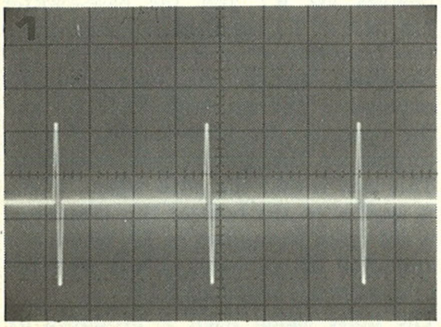
Capacitors:
C1* = 33 n
C2a/b*, C3a/b* = 15 n + 1 n
C4 = 22 µ/16 V
C5* = 10 µ/25 V

Miscellaneous:
S1,S2 = single pole, 16-way switch*

Semiconductors:
IC1 . . . IC4 = CD 4015
IC5 = CD 4049
IC6 = CD 4011
IC7,IC8 = 741
IC9 = CD 4066

* see text

1



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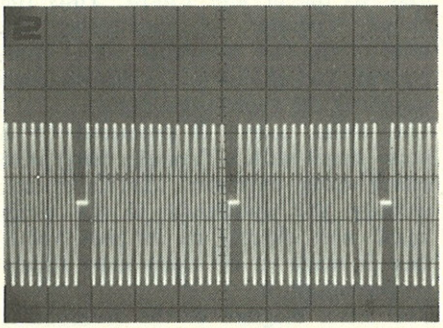

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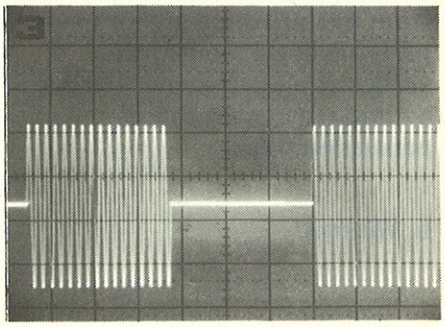

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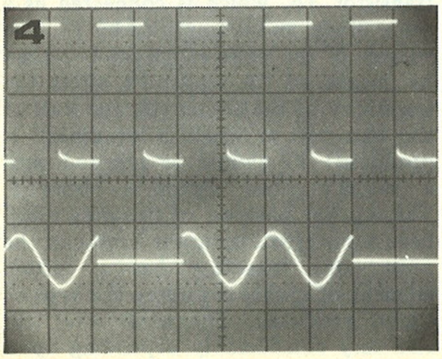

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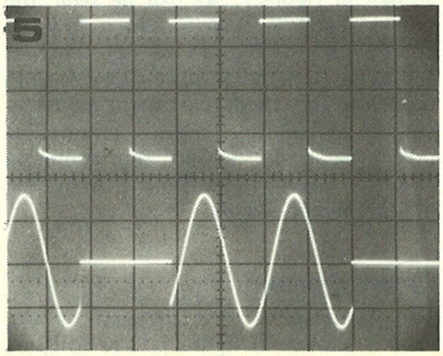

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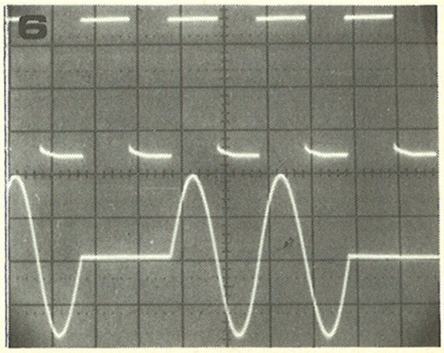
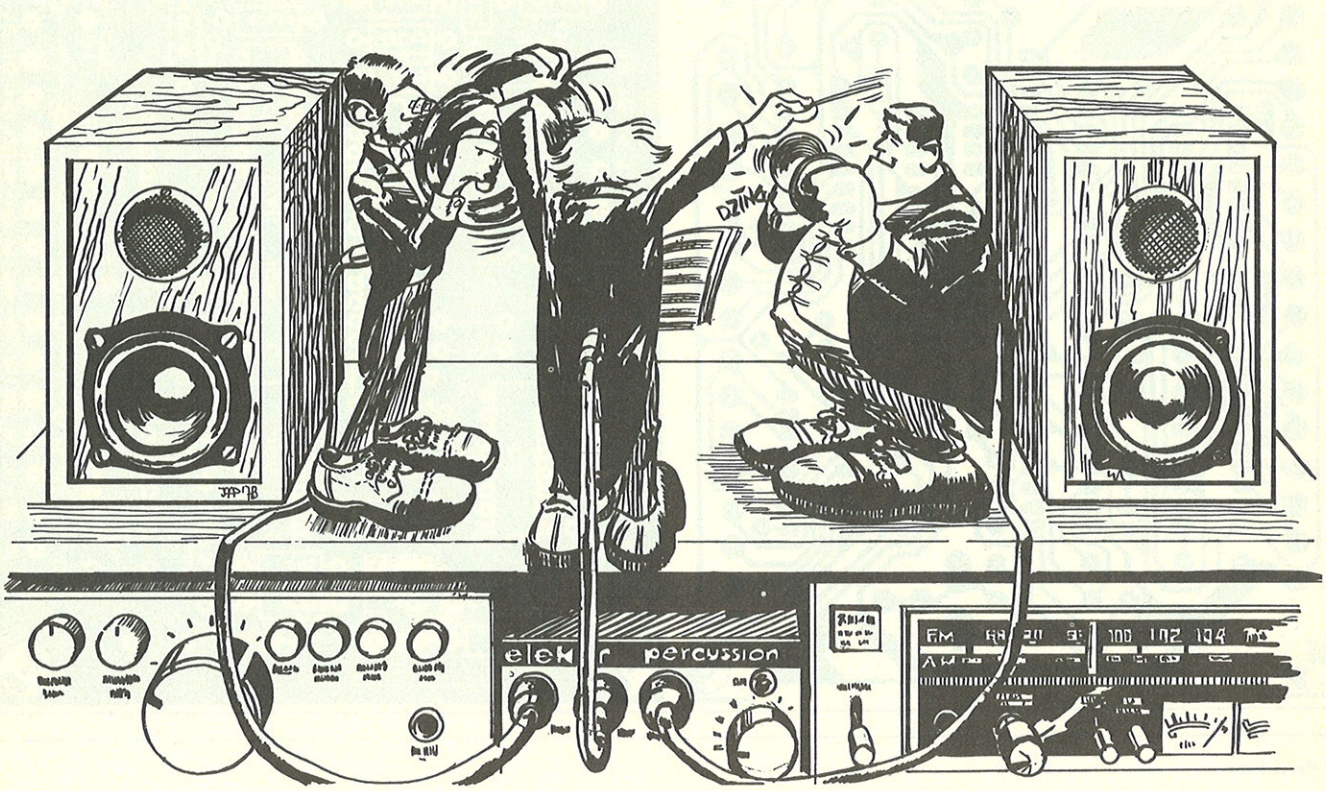


disco drums



A large number of contemporary pop records are aimed at the so-called 'disco scene'. A distinctive feature of most disco music is a heavy, repetitive and fairly complex percussive sound, which often has a characteristically artificial or 'funky' quality. With the aid of the circuit described here, records from the 'pre-disco era' or one's party tapes can be lent this authentic disco 'flavour' by the addition of a synthesised percussion track.

L. Witkam

It goes without saying that the 'drumbox' must have some means of detecting the beat of the piece of music being played, in order that the percussion be in time with the music. The simplest way of doing this is to utilise the fact that, almost invariably, the bass line in pop music lays down the beat for the rest of the instruments. Furthermore, the bass part tends to heavily accentuate the basic beat, making it easy to detect and follow. Thus the circuit operates by monitoring the level of the low frequency signal components and adding in the desired disco sounds at the appropriate points.

The drum sound is produced by a noise signal with a typically percussive attack-decay envelope. That is to say, initially the amplitude of the noise signal rises sharply to its peak value, then is made to die away more slowly (exponentially).

The block diagram of the drumbox is shown in figure 1. As can be seen, the music signal is first fed to a lowpass filter which eliminates all but the bass frequencies. The resulting signal is then rectified and used to control an optocoupler. When the latter is actuated, a noise signal is fed to the summing circuit, where it is mixed with the original music signal.

Circuit diagram

The complete circuit diagram of the unit is shown in figure 2. The lowpass filter is formed by T1 and T2. The filter slope is 18 dB per octave (i.e. the filter is third-order) and the turnover frequency is 40 Hz. The filter output is rectified by diodes D1 and D2, and smoothed by capacitor C7. This capacitor, which has a very short charge time, stores the instantaneous value of the bass part of the music signal. Thus when the voltage across C7 is sufficiently large, T3 is turned on. C7 then discharges via R7 and the base-emitter junction of T3, until, after a short time, this transistor is once more turned off. However, during the time that T3 remains turned on both LED D3 and the opto-coupler LED are lit, thereby turning on the opto-coupler transistor. This means that the noise signal, which is applied to the base of this transistor, is fed from its emitter to T4, where it is amplified before being mixed with the original music signal via R17.

The noise signal itself is produced by transistor T6, which is connected as a zener diode, and is amplified by T5. The volume of the noise signal can be varied by means of P3, whilst P1 alters the sensitivity of the circuit (i.e. the level of the bass part at which a 'drumbeat' is produced). P2 should be adjusted until a suitable noise signal is obtained. Varying the position of this preset will have some effect upon the timbre of the noise; one therefore has a certain element of choice regarding the type of sound produced. The noise level will also vary considerably depending upon

Figure 1. Block diagram of the 'disco drumbox'. Whenever the circuit detects a pronounced bass note in the passage of music, it adds the desired percussive effect in the form of a noise signal.

Figure 2. Complete circuit diagram. The operation of the circuit can be checked by testing the voltages at the points indicated. The values given in the table apply to quiescent conditions.

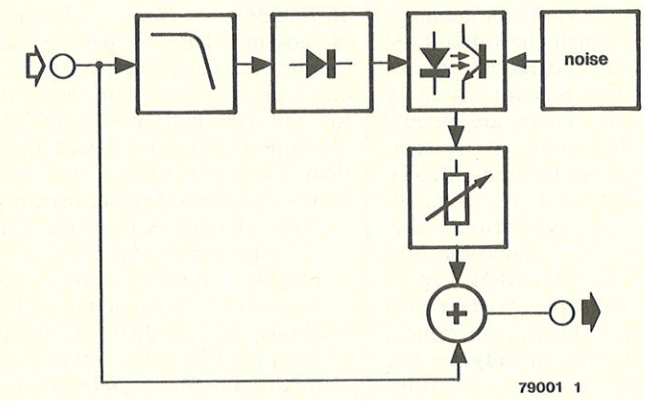
the sample of transistor used. Thus it is recommended that the noise generator be built first and tested using different transistors.

Construction of the circuit should not present any special problems. A T111 or T112 from Texas Instruments can be used for the opto-coupler. Both types are available in a six-pin DIL package. The pinout details given in the circuit diagram apply to both versions.

The quiescent current consumption of the circuit is roughly 3 mA; maximum consumption (during each 'beat') is approximately 40 mA, which means that, if desired, the unit can be powered by battery. The operation of the circuit can be checked with the aid of the measurement points and test voltages indicated in the circuit diagram.

Although in theory the unit can be inserted at any point in the (pre-) amplifier chain, it is recommended that it be placed before the volume control of the amplifier. The reason for this is that otherwise it would be necessary to alter the setting of P1 every time one adjusted the volume control. ⏮

1



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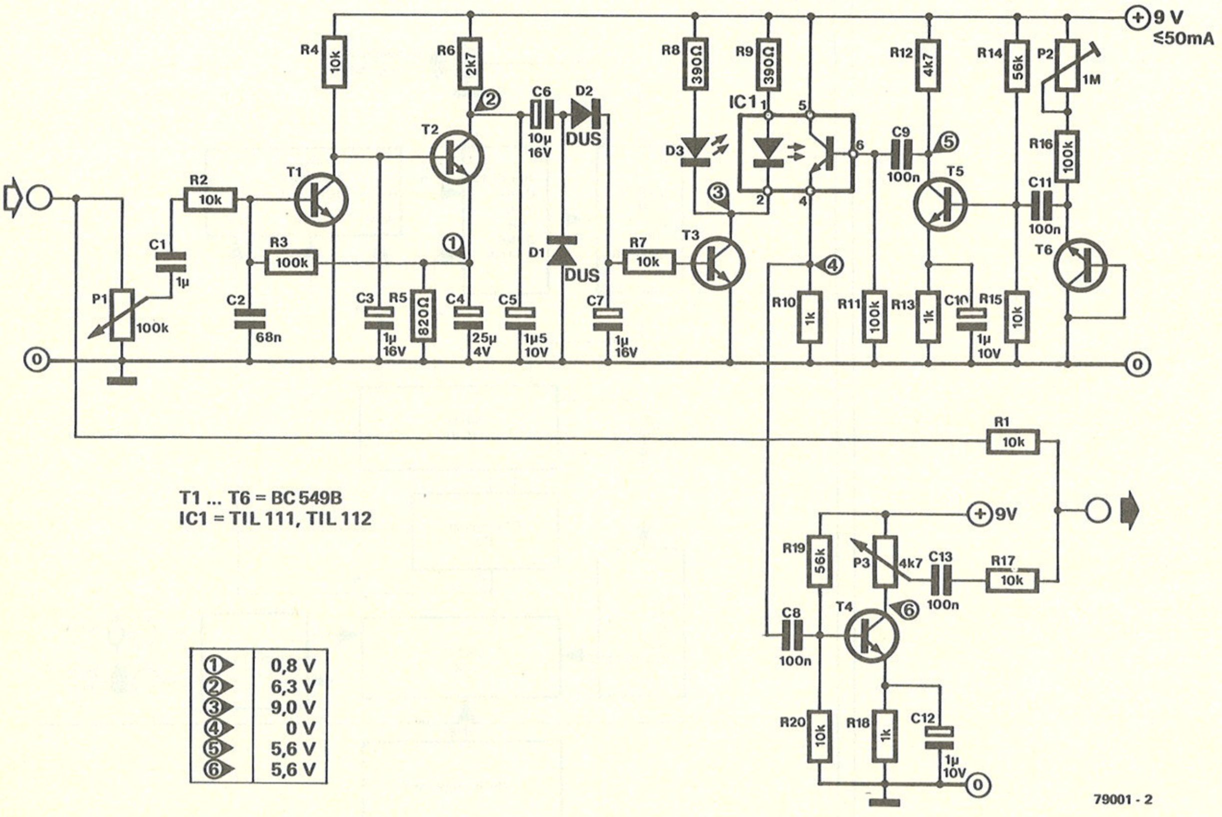


①	0,8 V
②	6,3 V
③	9,0 V
④	0 V
⑤	5,6 V
⑥	5,6 V

elekterminal

Low cost video terminal for µP/TV typewriter applications

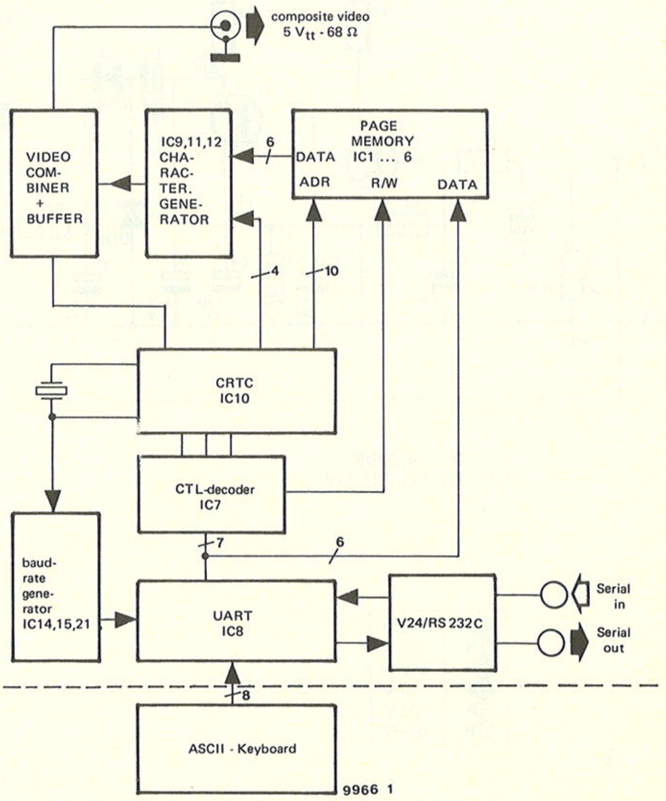
There is no doubt that by far the most convenient and elegant method of displaying data from a microprocessor is on a Visual Display Unit (VDU). When used in conjunction with an ASCII keyboard (such as that described in last month's issue of Elektor) the video interface circuit described here forms a complete video data terminal which can be used with the Elektor SC/MP system or any microprocessor system possessing a serial input/output facility.

The video terminal described in this article is of the serial (i.e. non memory-mapped) type, in which the video RAM used to store the characters to be generated on the screen is not shared by the microprocessor. There are several advantages of this type of system: firstly the terminal can be used independently (i.e. is not tied to a microprocessor) as a 'TV typewriter'. Secondly, the unit is TTY compatible, and in conjunction with a MODEM, can be employed to transmit/receive data over the telephone line. Thirdly, since most microprocessor systems already possess serial input/output routines, it means that the terminal can be used with the vast majority of different µP's and that the necessary device driver software is for the most part already present.

The Elekterminal uses one of the new single-chip CRT controllers, the SF.F 96364 from Thomson-CSF (Sescosem). Due in part to the large number of functions assumed by this one chip, the complete video interface for the terminal uses only 21 ICs, is accommodated on a board little larger than Eurocard format, yet offers the following comprehensive features:

- 1024 characters per page, formatted as 16 lines x 64 characters
- plug-in option allows character memory to be expanded to 16 pages
- choice of six different Baud rates: 75, 110, 150, 300, 600 or 1200
- programmable serial interface characteristics: i.e. choice of 6- or 7-bit ASCII code, even, odd or no-parity, 1- or 2 stop bits generation.
- choice of TTL or RS232C voltage levels

1



- normal (white on grey) or inverted (black on grey) video signal
- sophisticated cursor control and screen scrolling functions provided in hardware

Block diagram

The block diagram of the Elekterminal is shown in figure 1. A detailed description of the ASCII keyboard was contained in last month's issue, thus the remainder of this article is devoted to the video interface card proper.

The ASCII output of the keyboard is fed directly to the UART. UART stands for Universal Asynchronous Receiver/Transmitter. This is an LSI IC which accepts data, whether in serial or parallel form, from a peripheral device (keyboard, modem) and transmits this data with appropriate serial-parallel or parallel-serial conversion to the CPU or video interface. Basically the UART allows the keyboard, VDU and CPU to communicate with one another. A more detailed description of this important IC is contained later in the article.

To be able to transmit data at different speeds, a programmable Baud rate generator is required. As was explained in the article on the cassette interface (Elektor 36), the Baud rate is defined as the total number of bits including control bits such as stop and parity bits which are transmitted in one second. The programmable Baud rate generator generates a number of frequencies which are 16 x the desired Baud rate. The output frequencies are derived by dividing down a clock input obtained from the crystal oscillator of the CRTC.

The CRTC is without doubt the most important component in the entire circuit. CRTC stands for Cathode Ray Tube Controller, however it might be more accurate to describe the chip as a 'video processor'. However one calls it, the device is another LSI IC which performs a wide variety of control functions with a minimum of peripheral hardware. In the past, video interface cards required a veritable mountain of discrete logic ICs to perform the tasks which are now assumed by this single chip. Among other things the CRTC generates the line and field sync pulses of the video signal, is responsible for the addressing of page memory, and controls the character generator. The chip also provides cursor control and screen scrolling in hardware. Like the UART, a more detailed discussion of the CRTC is contained later in the article.

The page memory, which holds the data to be displayed on the screen, is formed by a number of static RAMs. The entire memory is scanned once every frame (20 ms). The ASCII code which is stored in page memory is converted into a form suitable for display with the aid of a character generator; after parallel-serial conversion it is then added to the horizontal and vertical sync pulses in the video combiner. The latter provides a 5 V_{pp} signal which can be fed direct to a video monitor or else via a VHF/UHF modulator (such as that contained in the October issue of Elektor this year) to the aerial input of a domestic TV receiver.

The only section of the circuit which remains to be discussed is the CTL decoder. This is basically a ROM which decodes the ASCII character transmitted by the UART and informs the CRTC whether it is a control signal (non-printing code) or a character to be displayed on the screen.

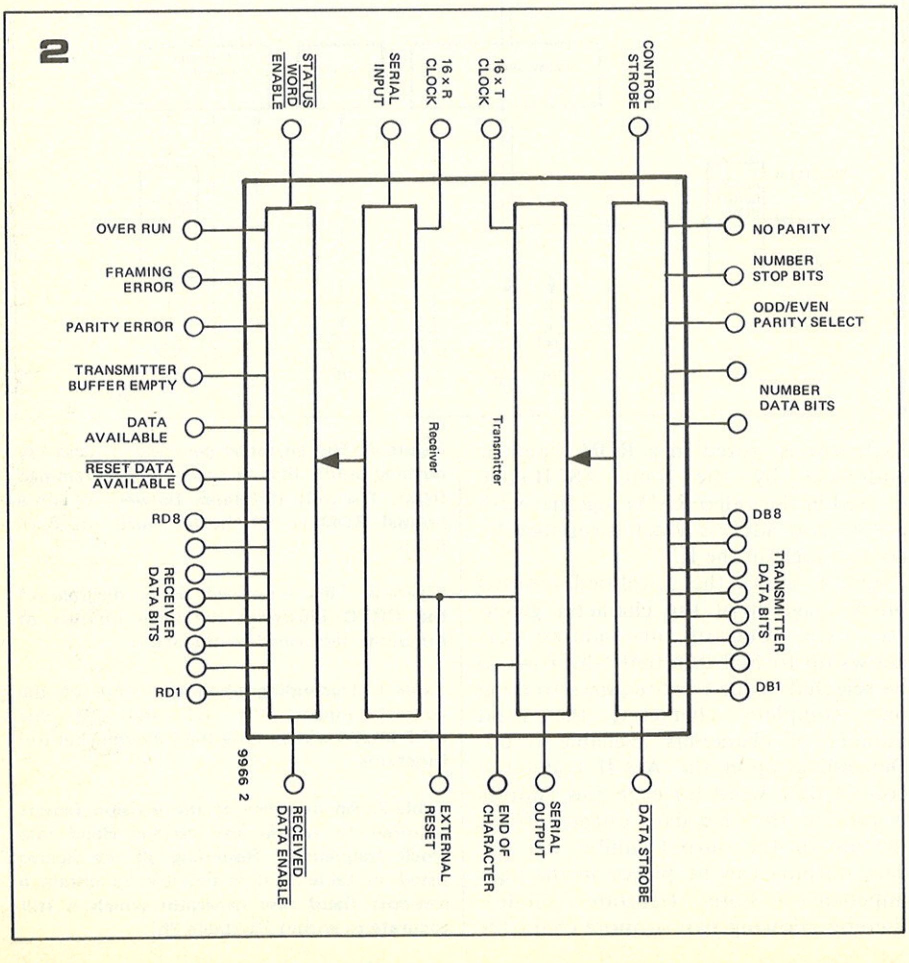
UART, character generator and CRTC

Since many readers may be unfamiliar with these important devices, it is worth while taking a closer look at just exactly how they operate.

UART

The block diagram of the AY-5-1013 UART which is used in the Elekterminal is shown in figure 2. In fact the UART can be thought of as two ICs (a transmitter and a receiver) which are housed in the same package and which combine certain functions in order to economise on the number of terminal pins. The UART is basically a device which provides asynchronous control of data communications, that is to say it is capable of both receiving and transmitting data at different rates, as well as performing parallel-serial and serial-parallel conversions, adding or deleting the necessary control and error detecting bits as required.

2



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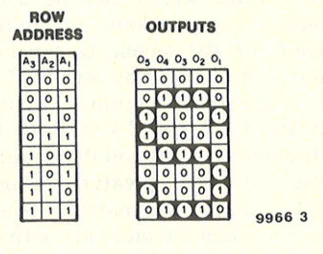


A3	A2	A1	O5	O4	O3	O2	O1
0	0	0	0	0	0	0	0
0	0	1	0	1	1	1	0
0	1	0	1	0	0	0	1
0	1	1	1	0	0	0	0
1	0	0	0	1	1	1	0
1	0	1	0	0	0	0	1
1	1	0	1	0	0	0	1
1	1	1	0	1	1	1	0

Figure 1. Block diagram of the Elekterminal.

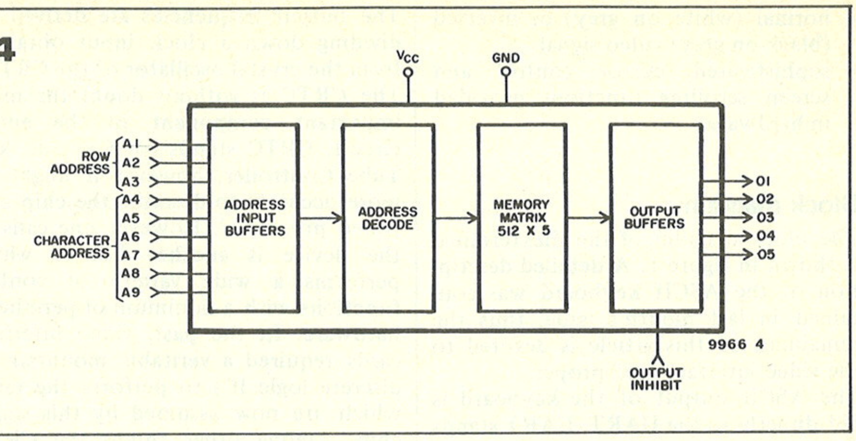
Figure 2. Simplified internal block diagram of the UART.

Figure 3. Characters are generated by means of an 8 x 5 dot matrix. The top row of dots remains permanently extinguished.

The transmitter and receiver have independent reference clock inputs, which determine the rate at which the data flow occurs, the UART can thus be used for both code- and speed conversion. The Baud rates are determined by the output frequency of a programmable Baud rate generator contained on-chip. The output frequency of the Baud Generator is 16 x the Baud rate.

Data are fed to the transmitter section of the UART (e.g. the ASCII output of the keyboard) in parallel form. The UART converts the parallel code into a serial data stream, adding the necessary start-, stop- and (if desired) parity bits. The system user can program the format of the transmitted or received serial character to suit his own requirements. That is to say that he has the choice of one or two stop bits, odd, even or no parity bit, and of selecting a 5, 6, 7 or 8-bit data word. The receiver section of the IC does exactly the opposite of the transmitter, i.e. it deletes the start and stop bits from the received serial character, checks for parity errors (which are flagged by setting the parity-error output), and presents the data in parallel form at the data outputs. When using the UART as a Baud rate- or code converter the data at the receiver outputs are fed to the data inputs of the transmitter; code conversion is performed by means of a ROM decoder connected between the two sections.

4



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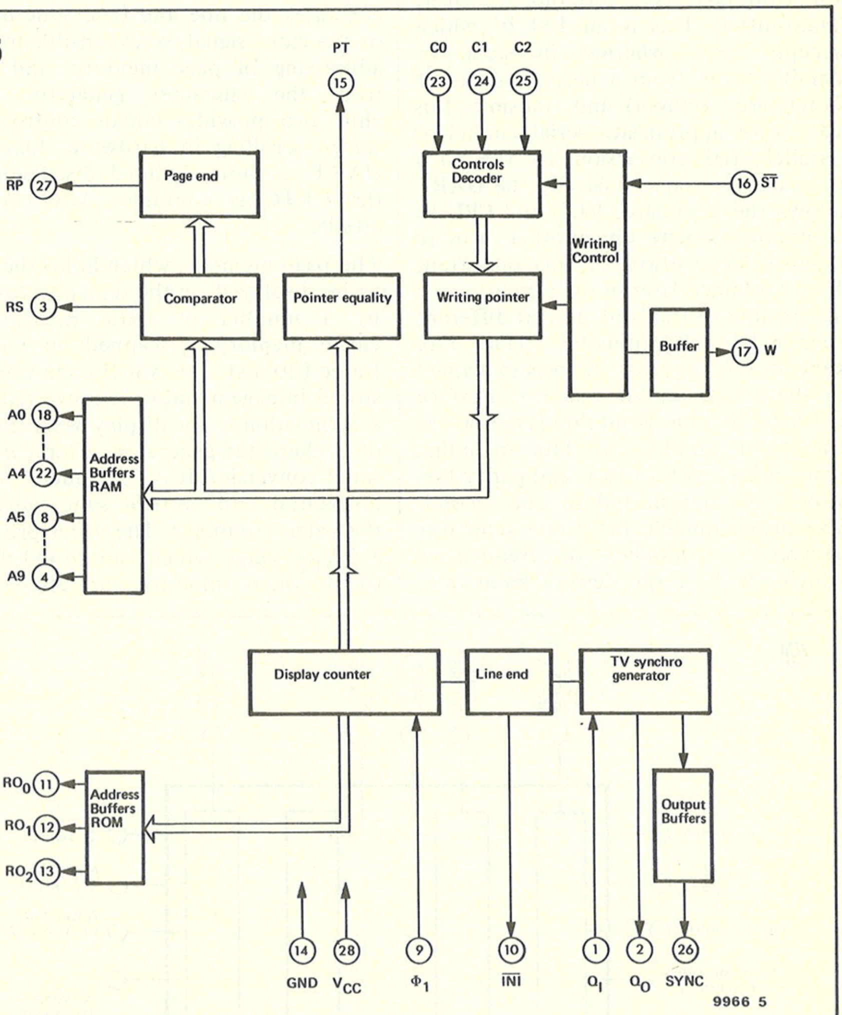


Figure 4. The character generator is basically nothing more than a specially programmed ROM. The only difference between it and a normal ROM is the shorter word length of 5 bits.

Figure 5. This simplified block diagram of the CRTC illustrates the large number of functions performed by the one IC.

Table 1. Depending upon the state of the control inputs, C0, C1 and C2, the SF.F 96364 will execute the following control functions.

Table 2. An overview of the division factors required to obtain the various Baud rate clock frequencies. Rounding up the figures listed in table 2a it is possible to obtain a low-cost Baud rate generator which is still accurate to within 1% (table 2b).

Character generator

Less complex than the UART, but just as important is the character generator. This IC is responsible for translating the ASCII code stored in the video RAM into a format which can be used to generate the equivalent alphanumeric characters on the screen. In general the characters are formed by means of a dot matrix, the most common types of which are 5 x 7 and 7 x 9. Both types have their advantages and disadvantages. Because of the greater resolution available the 7 x 9 matrix produces characters which are more attractive and have greater detail. However the larger number of dots in the matrix requires a corresponding increase in the bandwidth of the video signal. With 64 characters per line this bandwidth is several Megahertz too large for conventional TV receivers, and results in poor picture definition. For this reason the 7 x 9 matrix is generally reserved for use with video monitors.

Although the characters generated by a 5 x 7 matrix are somewhat simpler, it is still possible to obtain excellent definition using a normal domestic TV receiver which has a video input. Even with the unavoidable picture degradation caused by a VHF/UHF modulator, the legibility of the resulting display is still perfectly satisfactory.

The format of the matrix produced by the character generator is illustrated in figure 3. The information contained in each row is stored in a ROM which is addressed by the 6-bit ASCII code (stored in the video RAM) together with a 3-bit row address which is supplied by control logic in the IC.

Figure 4 shows the simplified internal block diagram of the character generator. The total of nine address bits allows up to 512 different 5-bit rows to be selected; since 8 are required to form one complete character, the total number of characters available is 64. Depending upon the ASCII code, the correct data word for each row address is put on the five data outputs. With the aid of the output inhibit pin the data outputs can be placed in the high impedance state (tri-state mode), thereby allowing two or more character

Table 1.

	C_2	C_1	C_0	Execution time ms
Page erase and cursor home (top-left)	0	0	0	132
End of line erase and cursor return (at left)	0	0	1	8.3
Line feed (cursor down)	0	1	0	8.3
Inhibition of the character sent	0	1	1	8.3
Cursor left (one position)	1	0	0	8.3
Erasure of cursor-line	1	0	1	8.3
Cursor up (one position)	1	1	0	8.3
Normal character	1	1	1	8.3

Table 2a

Baud rate	f UART	division factor 1000 MHz	division factor 1008 MHz
75	1200 Hz	833.33	840
110	1760 Hz	568.18	572.73
150	2400 Hz	416.67	420
300	4800 Hz	208.33	210
600	9600 Hz	104.17	105
1200	19200 Hz	52.08	52.50

Table 2b

Comparison of division factors

Baud rate	1 MHz	1008 MHz
75	64 x 13	64 x 13 (+8)
110	44 x 13 (−4)	44 x 13
150	32 x 13	32 x 13 (+4)
300	16 x 13	16 x 13 (+2)
600	8 x 13	8 x 13 (+1)
1200	4 x 13	4 x 13

generators to be connected in parallel so as to provide the remaining 64 ASCII characters, lower case letters and special symbols.

CRTC

Almost all the major microprocessor manufacturers have already brought out a CRTC or are in the process of doing so. Most CRT Controllers are designed to be used in conjunction with a microprocessor, and some are even tied to a particular family of processor.

The device used here, however, is an exception to this rule, and the video interface card, of which it is the heart, can be used to form an independent VDU/TV typewriter as well as an output terminal for any microprocessor which has a serial output. The device in question is the SF.F 96364 from Thomson-CSF, which, as we shall see, provides all the control and timing signals required for screen display, as well as providing a number of sophisticated screen management facilities (cursor control and screen scrolling etc.)

A simplified block diagram of the SF.F 96364 is shown in figure 5.

One of the most important tasks of the CRTC is to generate the sync pulses required to display a video signal. With the aid of a simple on-chip crystal oscillator the SF.F 96364 provides a close approximation to the CCIR standard sync signal. Line and field sync pulses are both combined in the one sync waveform. The sync generator also drives the display counter which is responsible for the addressing of the character generator (i.e. providing the correct row address) and of the video RAM (page memory). In addition, the display counter provides information for the cursor- and page-end comparators. The cursor comparator supplies a signal which ensures that the cursor appears at the correct point on the screen. The page-end comparator allows the amount of addressable video RAM to be extended to include extra pages, since the RS output is used to enable the VDU to 'turn a page' in mid-screen. The $\overline{RP}$ output clocks the counter used to address the additional pages of character memory.

A detailed explanation of how the video RAM is extended will be contained in a subsequent article describing an add-on circuit which will permit the use of up to 16 pages of memory.

The above mentioned functions of the CRTC are of course indispensable, however the most important features of the device are almost certainly the screen formatting control functions which are available in hardware. Many less sophisticated video interface cards rely upon software routines to provide control of cursor and screen scrolling, which means that they are necessarily tied to a microprocessor. The SF.F 96364, however, can provide fairly sophisticated screen control options on-chip, allowing it to function independently.

As was stated in the description of the block diagram in figure 1, the CTL decoder provides a 3-bit instruction code which informs the CRTC that the ASCII character transmitted by the UART is in fact a non-printable control character. Depending upon the code applied to pins C_0, C_1 and C_2, the CRTC will perform one of the cursor control functions listed in table 1. Certain control instructions take a comparatively long time to execute, since they have to be carried out during blanking intervals so as to minimise display distortion.

As will be explained later, the number of control functions can be extended by manipulating the W-(Write-)signal; this facility is exploited in the Elekterminal.

Circuit

The 21 ICs and associated components which are shown in figure 6 form the complete circuit of the Elekterminal. All that is required to render the terminal operational is the addition of an ASCII encoded keyboard. Page memory, which holds the ASCII version of the characters to be displayed on the screen, is 6 bits wide and is formed by six 2102A4 1 K x 1 RAMs. The '4' in the type number indicates the access time of the device, which in this case is 450 ns. If character memory is to be expanded to several pages, it may well be worth investing in low power

6

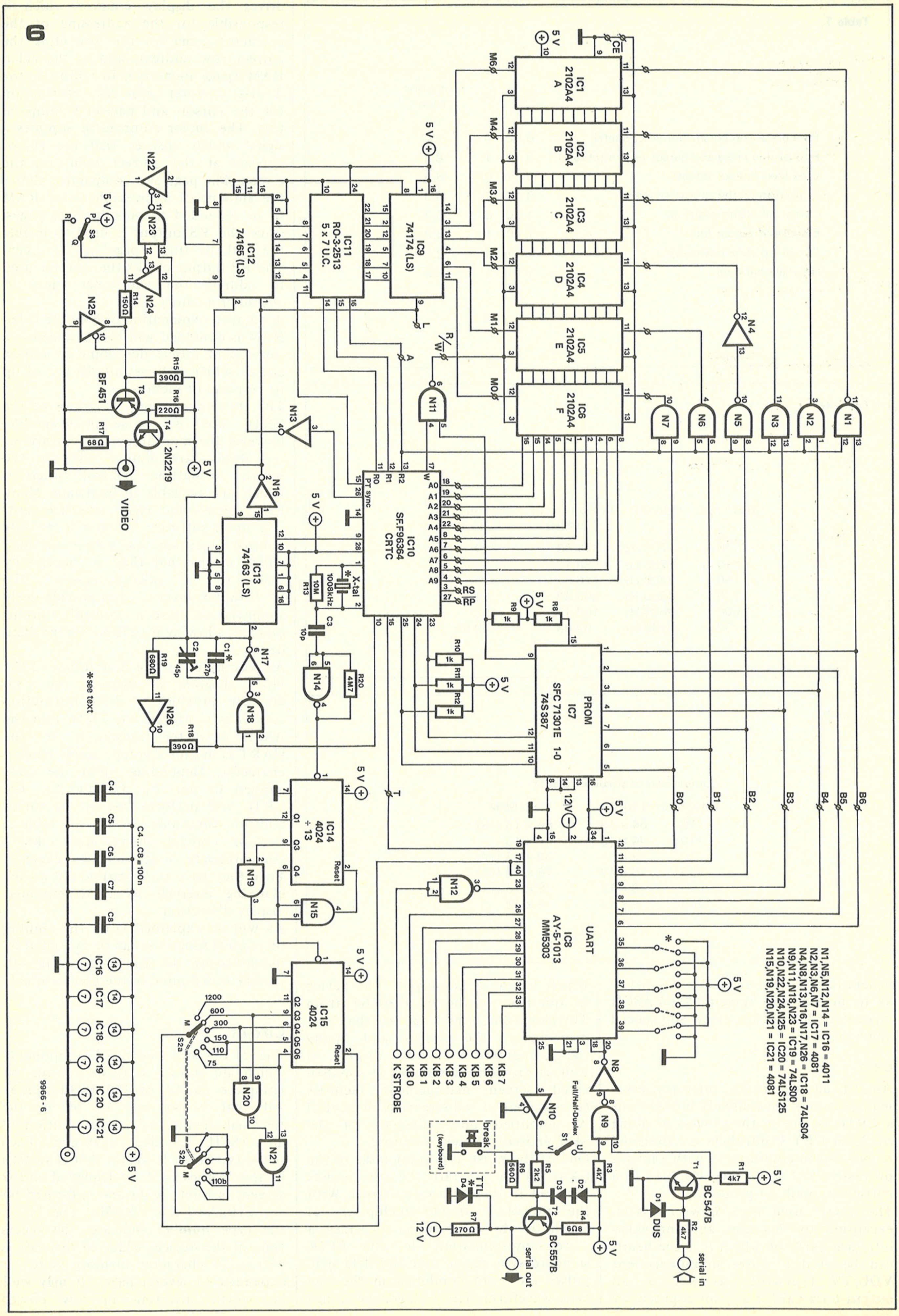

IC1 2102A4 A
IC2 2102A4 B
IC3 2102A4 C
IC4 2102A4 D
IC5 2102A4 E
IC6 2102A4 F
PROM IC7 SFC 71301E 1-0 74S387
UART IC8 AY-5-1013 MM5303
IC9 74174 (LS)
IC10 SF.F96364 CRTC
IC11 RO-3-2513 5 x 7 U.C.
IC12 74165 (LS)
IC13 74163 (LS)
IC14 4024 ÷ 13
IC15 4024
CE
R/W
X-tal 1008kHz
RS
RP
B0 B1 B2 B3 B4 B5 B6
KB 0 KB 1 KB 2 KB 3 KB 4 KB 5 KB 6 KB 7
K STROBE
break (keyboard)
TTL
Full/Half-Duplex
DUS
serial in
serial out
VIDEO
BC 547B
BC 557B
BF 451
2N2219
1200 600 300 150 110 75 110b
S2a S2b S1 S3
C4...C8 = 100n
* see text
N1,N5,N12,N14 = IC16 = 4011
N2,N3,N6,N7 = IC17 = 4081
N4,N8,N13,N16,N17,N26 = IC18 = 74LS04
N9,N11,N18,N23 = IC19 = 74LS00
N10,N22,N24,N25 = IC20 = 74LS125
N15,N19,N20,N21 = IC21 = 4081
9966 - 6

Table 3.

PIN	LEVEL	TRANSMITTED OR RECEIVED FORMAT
35	1	No parity bit
	0	Transmitted parity bit
39	1	Even parity
	0	Odd parity
36	1	2 stop bits
	0	1 stop bit
37 38	0 0	5 bits/character
37 38	0 1	6 bits/character
37 38	1 0	7 bits/character
37 38	1 1	8 bits/character

Table 4.

Function	Key	corresponds to
line-feed	LF	CTL J
carriage-return + erase to end of line	CR	CTL M
cursor up	VT	CTL K
cursor down	LF	CTL J
cursor left	BS	CTL H
cursor right	HT	CTL I
home cursor	FS	——
home cursor + page erase	FF	CTL L
scroll up (cursor down)	ESC	CTL [
carriage return (no erasure)	-- (GS)	CTL]
erase current line	-- (SUB)	CTL Z

Table 5.

	Positive logic			
Address	O_3	O_2	O_1	O_0
0 to 127	1	0	0	0
128 to 135	0	0	1	1
136	0	1	0	0
137	0	1	1	1
138	1	0	1	0
139	0	1	1	0
140	1	0	0	0
141	1	0	0	1
142 to 153	0	0	1	1
154	1	1	0	1
155	0	0	1	0
156	0	0	0	0
157	0	0	0	1
158, 159	0	0	1	1
160 to 254	1	1	1	1
255	0	0	1	1

memories (2102AL4), since they can lead to a saving in current consumption of up to roughly 30%.

Since each character is formed by 8 rows of 5 bits, the ASCII code stored in the page memory is read out 8 x every frame. With 64 characters per line, the memory is scanned in blocks of 64 words. IC10, i.e. the CRTC, ensures that the same block is scanned 8 times in succession, and that the character generator is provided with the correct row addresses. The outputs of the memory are not connected directly to the character generator, but to an intermediate latch (IC9). The memory address can thus remain one step ahead of the position on-screen, which means it has ample time to set up the following ASCII code on its outputs.

The 5-bit parallel 'row' data from the character generator is fed to a shift register (IC12), where it is converted into serial form and thus becomes suitable for video display. This shift register is driven by a 'dot-clock' with a frequency of approx. 11 MHz. The dot-clock generator is formed by N17, N18 and N26. Since all eight rows of a character must be positioned directly beneath one another, the dot-clock generator is synchronised by the CRTC. This is achieved with the aid of the $\overline{\text{INI}}$ line (see figure 5) which goes low after the 64th character, thereby stopping the dot-clock generator until the following line sync pulse.

All memory addressing is clocked by the dot-clock, since the 'character-clock', which, via the Φ1-input, drives the address counter in the CRTC, is derived from the dot-clock signal via a divide-by-eight counter (IC13).

The frequency of the dot-clock, which can be varied by means of C2, determines the width of a character: the lower the frequency the wider the character. The minimum usable frequency is determined by the available space on the TV screen. If too low a frequency is chosen, the characters will run off the edge of the screen. On the other hand, if the frequency is too high, the characters will be compressed into one portion of the screen, with a consequent loss of definition and legibility. Thus it is important that C2 be adjusted so as to obtain an optimal picture on-screen.

The spacing between character lines is regulated by the CRTC, which blanks the video signal for the period of four line scans. Between successive character lines there is therefore a space of half a line. Spacing between the actual characters is provided by the shift register, IC12. Since this is an eight-bit shift register and the character generator output is only five bits wide, each character can be preceded by two unmodulated dot columns and followed by one such column. Between each character there is thus a space three dots wide. The fact that, including spaces, each character is in fact eight bits wide explains why the character clock is derived from the dot-clock via a divide-by-eight counter.

The serial data stream output by the shift register is also available in its inverted form. One can therefore choose between a positive (white on grey) or negative (black on grey) video signal.

The video combiner is built round N22 . . . N25. Depending upon the position of S3, N22 . . . N24 provide a video signal of appropriate polarity. N23 not only inverts the signal at S3, but also inhibits the inverted video signal during the sync period. This causes the current through N25 during the sync pulses to be limited to an acceptable value.

The voltage divider network formed by R14 and R15 determines the ratio between the amplitude of the video signal and that of the sync signals. With the values shown the black level is around 30%.

Figure 6. Complete circuit diagram of the video interface for the Elekterminal. With the addition of an ASCII keyboard, which is connected to the K strobe- and KB0 . . . KB7 lines, the circuit forms a complete video data terminal.

Table 3. The programmable serial interface characteristics of the UART. This table applies both to the AY-5-1013 and to the MM5303. A recommended bit format is shown shaded; this format corresponds to the arrangement of wire links illustrated in figures 6 and 8.

Table 4. In addition to the control functions listed in table 1, the 4-bit PROM decoder offers several extra possibilities. These extra control functions can be generated either by special keys or with the aid of the control key and one of the data keys.

Table 5. The program for the PROM decoder IC7.

The video combiner is followed by a buffer stage which has an output impedance of 68 Ω, and to which one can directly connect a length of coaxial cable. Assuming that the cable is terminated with the correct impedance it is possible to use lengths of over 10 m without any problems. The buffer stage has the effect of increasing the black level to around 35%; this can of course be corrected by altering the values of R14 and R15, however the increase in sync signal level does no harm and the adjustment is not really worth the bother.

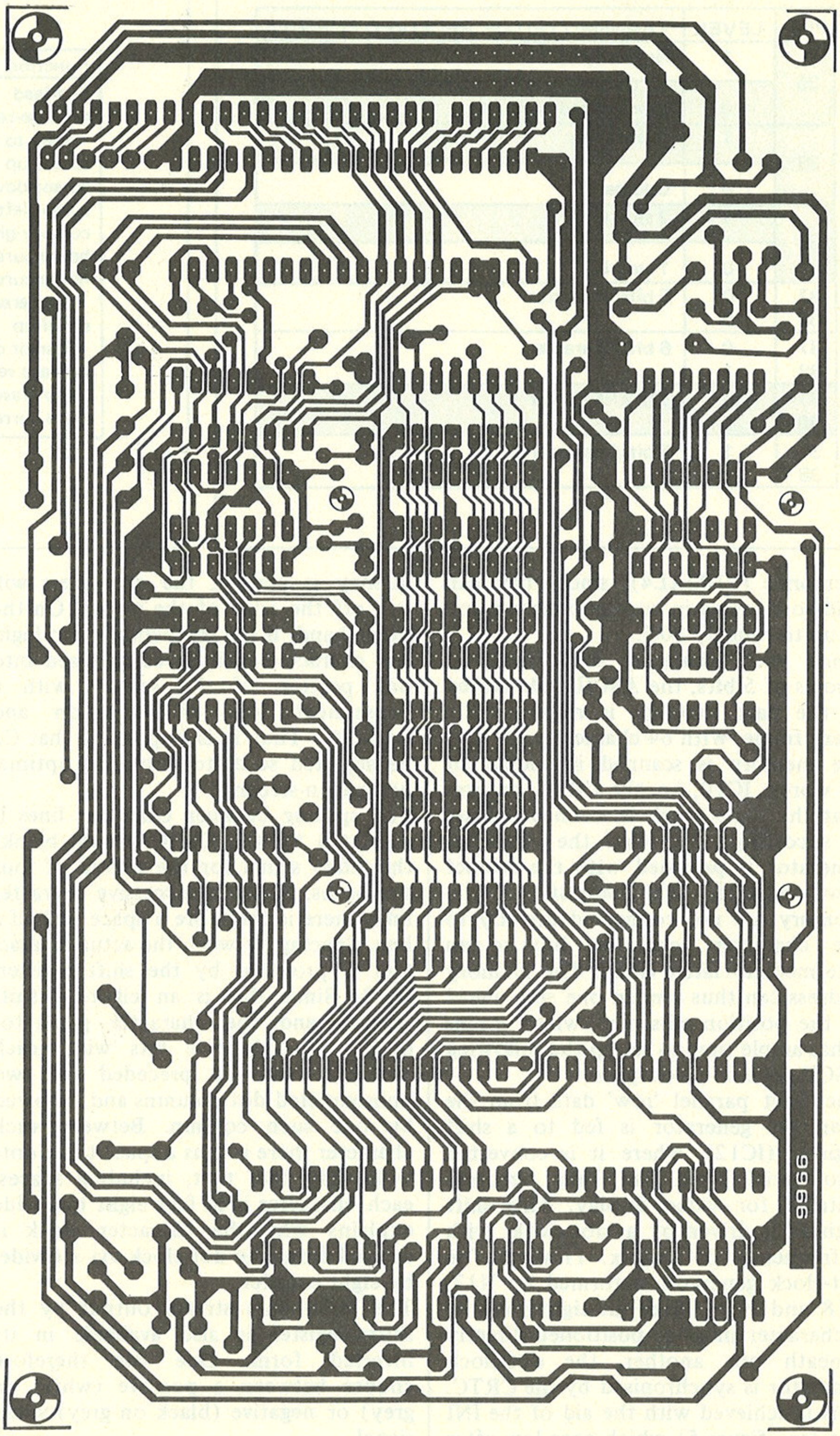
So much for the circuitry which is responsible for actually generating the video signals; there remains the circuit which allows the unit to communicate with peripheral devices such as the CPU and/or keyboard. The most important interface element is of course the UART, the basic operation of which has already been described. As was stated then, the rate at which data is transmitted by the UART is determined by a clock signal, whose frequency is 16 x the desired Baud rate. Normally a monolithic Baud rate generator is employed to provide the clock signal, however these ICs are still fairly expensive and require a 1 MHz crystal to supply the basic clock frequency from which the 'x 16' clock signals are obtained by means of frequency division.

An obvious alternative is to make use of the crystal oscillator for the CRTC to provide the necessary clock frequencies. This can be done quite simply by first of all amplifying the signal at the output of the oscillator (with the aid of N14), and then feeding it to a programmable divider (IC14 and IC15). The accuracy of the clock frequencies obtained thereby is better than 1%. Generally speaking, the methods adopted for the transmission of data allow a reasonable tolerance in the accuracy of signals, so that a deviation in the region of 1% remains a perfectly acceptable figure. Table 2 lists the relationship between the UART frequencies and the (theoretical) division factors (2a) obtained with crystal frequencies of 1 MHz and 1008 kHz. The manufacturer of the SF.F 96364 recommends a crystal frequency of 1008 kHz in order to avoid interference from the mains frequency. In practice, however, a 1 MHz crystal is perfectly satisfactory.

As can be seen from table 2, keeping to an accuracy of 1% and rounding up to the nearest whole figure produces identical division ratios for both crystal frequencies. The result is a Baud rate generator at roughly 20% the price of a monolithic type. Results obtained in practice have failed to indicate that this approach has any untoward effect upon the performance of the circuit.

Once provided with suitable clock frequencies, the UART can receive and transmit data at any one of six different Baud rates, which are selected by means of switch S2. An important point about most UARTs is that the output logic levels are often not TTL-compatible. The most common voltage levels used are the so-called RS232C and V24 norms. These two norms, which are virtually identical and more or less interchangeable, have the advantage of minimum signal levels of +5 V (logic '1') and −5 V (logic '0') and maximum levels of + and −15 V respectively. Thus they clearly have a much greater noise immunity than TTL logic levels.

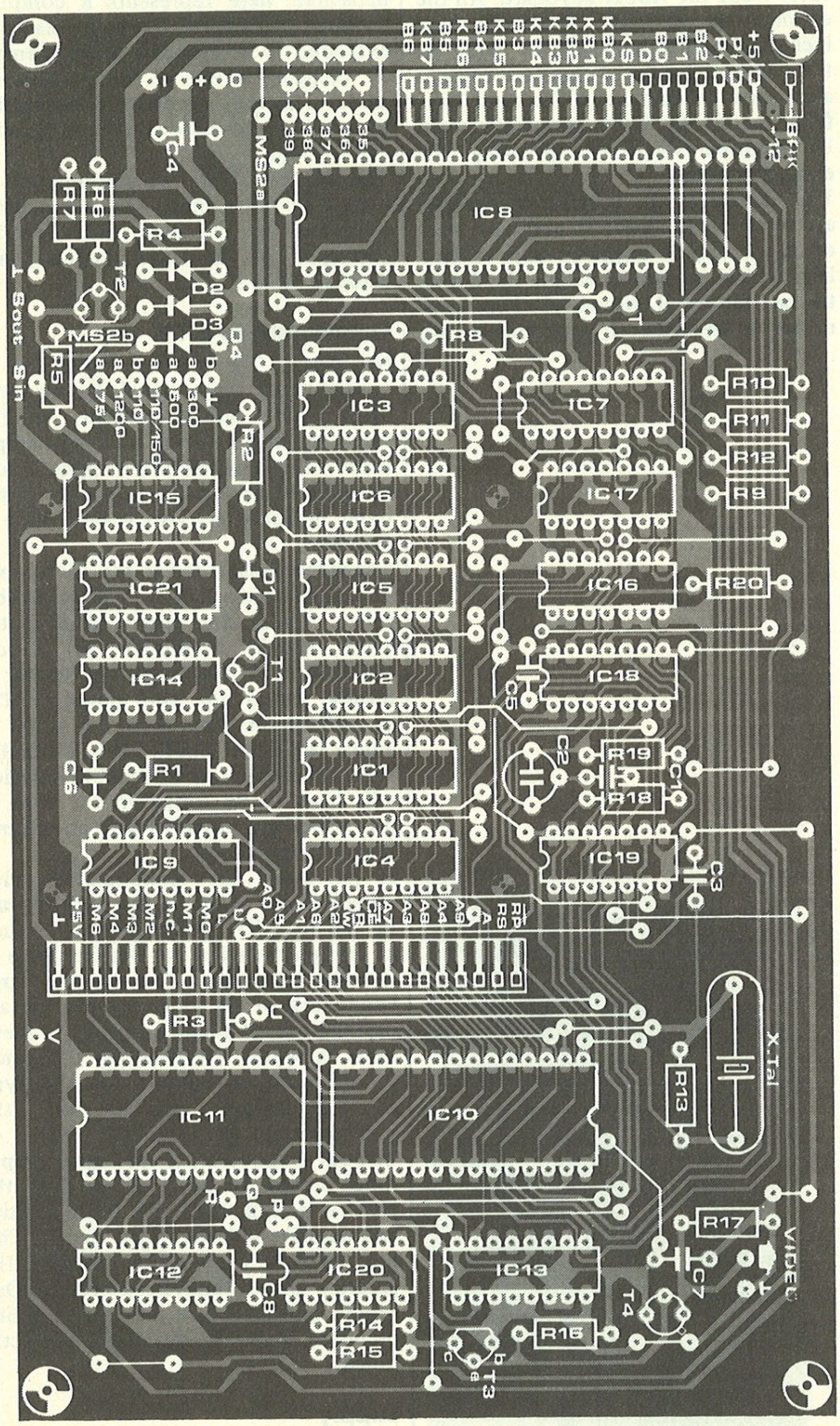
7



The circuit described here attempts to reach a compromise solution by employing a discrete interface design which is compatible with both RS232C/V24 and TTL voltage levels. If the output signal is required to drive TTL loads, then D4 should be included. This diode limits the output voltage to −0.6 V. Without the diode the output voltage can swing between +5 V and −12 V. The output impedance is deliberately held low in order to facilitate matching with the cable.

As was mentioned earlier, the format of

8



Parts list to figure 6:

Resistors:
R1 . . . R3 = 4k7
R4 = 6Ω8
R5 = 2k2
R6 = 560 Ω
R7 = 270 Ω
R8 . . . R12 = 1 k
R13 = 10 M
R14 = 150 Ω
R15 = 390 Ω
R16 = 220 Ω
R17 = 68 Ω
R18 = 390 Ω
R19 = 680 Ω
R20 = 4M7

Capacitors:
C1 = 27 pF (see text)
C2 = 45 pF trimmer
C3 = 10 pF
C4 . . . C8 = 100 n

Semiconductors:
D1 . . . D4 = DUS
T1 = BC 107B, BC 547B or equ.
T2 = BC 177B, BC 557B or equ.
T3 = BF 451
T4 = 2N2219

ICs:
IC1 . . . IC6 = 2102-1,2102A4, 2102AL4
IC7 = SFC 71301E 1-0 (pre-programmed) or equivalent eg 74S387 (to be programmed as shown in table 5)
IC8 = AY-5-1013,MM5303
IC9 = 74LS174
IC10 = SF.F 96364 (Sescosem)
IC11 = RO-3-2513
IC12 = 74LS165
IC13 = 74LS163
IC14,IC15 = 4024
IC16 = 4011
IC17,IC21 = 4081
IC18 = 74LS04
IC19 = 74LS00
IC20 = 74LS125

Miscellaneous:
S1 = SPST switch
S2 = 2 pole 6 way switch
S3 = SP changeover switch
P.c.b. connectors (female): type ITT-Cannon G09
1 x 22 way (keyboard)
1 x 26 way (extension card)
For keyboard cable (male): type ITT-Cannon G09
1 x 22 way
X1 = 1008 kHz or 1000 kHz crystal

Figures 7 and 8. Track pattern and component overlay of the p.c.b. for the Elekterminal (EPS 9966).

the serial output/input signal can be programmed by the system user. The number of stop/start bits, choice of parity bit and of data word length can be selected by making the appropriate connections to pins 35 . . . 39. The details are listed in table 3, where a preferred format (7-bit code with even parity) is shown shaded. If desired the parity bit can be omitted (no parity) since although the UART checks for parity errors in the received signal, the parity-error output is not brought out externally. Thus the parity bit is only of use to the device receiving a character *transmitted* by the UART.

The Elekterminal is capable of being operated in both the full-duplex and half-duplex mode. In a full-duplex system, where the terminal is linked to a μP, the CPU and terminal communicate in both directions simultaneously. That is to say that the computer is programmed to echo what is transmitted (from the keyboard via the UART) back to the terminal display. In half-duplex systems the terminal is normally wired up so that the screen responds directly to the keyboard. Switching between half- and full-duplex is accomplished with the aid of S1, which is included between the serial output- and input pins of the UART.

The UART relays the ASCII code from the keyboard (or CPU) onto the data bus lines B0 . . . B6, where it is picked off by the CRTC and character memory. Before the data reaches the RAMs, however, it is converted from 7- to 6-bit ASCII code; bit 5 is ignored and bit 6 inverted. In addition, gates N1 . . . N7 offer the possibility of forcing the 'space' code (100000) onto the data inputs of the RAMs, so that, if the appropriate control code is applied to the CRTC, an entire line or the complete screen can be erased. These are in fact only two of the many control functions which the Elekterminal possesses.

The 7-bit ASCII control codes are detected and decoded by a 256 x 4 ROM (IC7), which forms the CTL decoder of figure 1. The ASCII code is placed on the address inputs of this ROM and the code which appears at the data outputs is fed to the C0, C1 and C2 control lines of the CRTC.

Table 1 has already listed a number of the control functions offered by the CRTC. However by utilising the read/write line of the RAMs it is possible to extend these. Table 4 provides an overview of all the various cursor control and screen scrolling functions which are provided by the Elekterminal. The majority of these functions can be selected by an individual key on the Elektor ASCII keyboard which was published last month. However, with the exception of 'home cursor', all the above functions can also be obtained using the control key and the appropriate data key, which means that the video interface is compatible with keyboards other than the Elektor model.

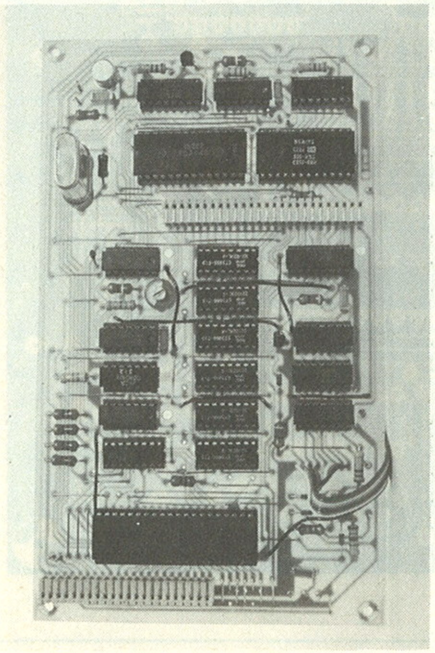
The PROM decoder for the CRTC is programmed as shown in figure 5. This device is available from a number of manufucaturers under the type number 74S387. Since only 128 combinations are possible with a 7-bit code, only half of the PROM is used.

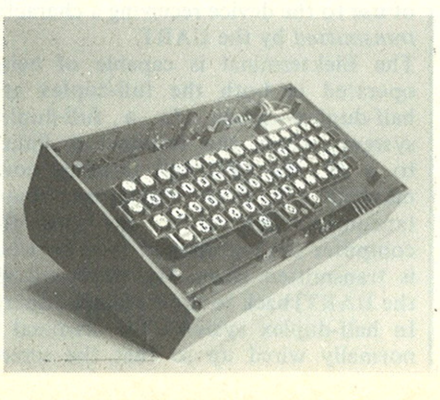
Printed circuit board

The printed circuit board for the video interface card (see figures 7 and 8) is not much larger than Eurocard format, but nonetheless is single-sided. Because of this there are a considerable number of through connections to be made (approx. 60 in all), however the extra effort required is more than compensated for by the lower cost of a single-sided board. The p.c.b. has been specially designed to accomodate an extension board to increase the number of memory pages to 16. The latter (which will appear shortly) simply plugs into the video interface card with tne aid of edge connectors. At the left hand end of the video interface board is a simple connector to accept the ribbon cable from the ASCII keyboard. All the connections to the keyboard, i.e. including supply lines, can be made via the connector socket. This connector is also used to bring out the data lines from the UART. These connections will be required when incorporating the extension board.

The second p.c.b. connector provides access to all the address and data lines of the character memory and to two lines which are used to enable the RAMs to be addressed properly. This connector is designed to accomodate the memory extension board. It should be emphasised that the Elekterminal as presented here represents a complete output peripheral, which can be extended to accomodate more memory by plugging in one or more additional cards. The only on-board modification required is the removal of one through connection.

The UART (IC8) is programmed by means of wire links. The connections indicated on the component overlay correspond to the recommended format listed in table 3.





Connection to a TV

Not every TV has an input for an unmodulated video signal, but in those cases where one is present, or if a video monitor is being used, the amplitude of the terminal output signal has to be adjusted to suit the sensitivity of the input in question. This is best done as follows:

The video signal is fed to the TV receiver or monitor via a length of coaxial cable (50 . . . 75 Ω). The 'receiver-end' of the cable should terminate in a low impedance. A 100 Ω potentiometer is ideally suited for this purpose. The potentiometer can then be used to adjust the signal amplitude to a suitable value. Naturally, an alternative solution will have to be found in the case of sets which are provided with an internal terminal impedance.

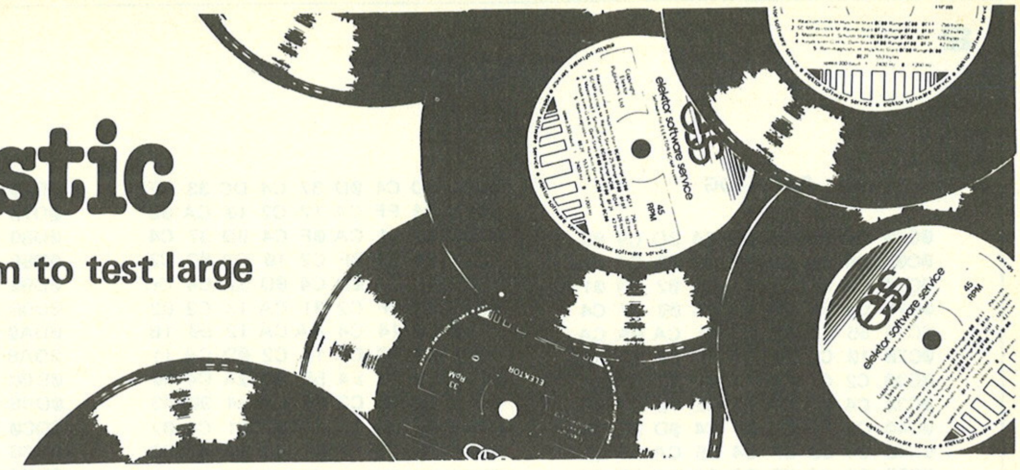
If an input for unmodulated video signals is not available the output must be fed to a VHF/UHF modulator such as that published in the October issue of Elektor this year. Due to the large bandwidth of the video signal a certain degradation of picture quality is inevitable, however the resultant definition is still quite acceptable for the type of application for which the Elekterminal is intended. With or without a modulator, the signal amplitude should be adjusted so that the picture is 'sync-ing' with both positive and negative polarity video signals. This can easily be checked by changing the polarity several times in succession. One should also first ascertain that the line oscillator of the TV receiver is correctly tuned.

Supply

Using normal memory ICs the current consumption of the circuit is around 750 mA (5 V). If low power memories are used, however, consumption drops to around 550 mA (5 V). The −12 V supply draws well under 100 mA. This means that the circuit could be powered using the spare capacity of an SC/MP system, assuming the latter was not driving a large amount of additional memory. Alternatively, a better idea might be to use the SC/MP power supply design to form a separate supply for the Elekterminal, especially if one bears in mind that extending the number of character memory pages will push up the current consumption. ◼

RAM diagnostic

An SC/MP program to test large sections of RAM



The more RAM which one adds to a μP system, the more difficult it becomes to trace any faults which may occur on one of the memory boards. Think, for example, of how tedious it would be to have to step through every location of a 4 K RAM card! Fortunately, however, with the aid of the right software, we can make the microprocessor itself do all the hard work. After all, computers are supposed to be ideally suited to taking over boring and repetitive tasks from humans. The following program can be used to test any block of memory larger than ½ K and will indicate the location of any faults which exist.

H. Huschitt

A static Random Access Memory basically consists of a large number of flip-flops and address decoders. These decoders are either integrated on the RAM chips themselves, or else are formed by discrete (TTL and CMOS) logic ICs. However, if somewhere within a section of memory there is a faulty IC, a short circuit or a loose contact, there is a good chance that the program which is contained in that section of memory will fail to function properly. A suitable debug program must therefore be able to check for such a malfunction.

The flow diagram of the RAM-diagnostic program is shown in figure 1.

1

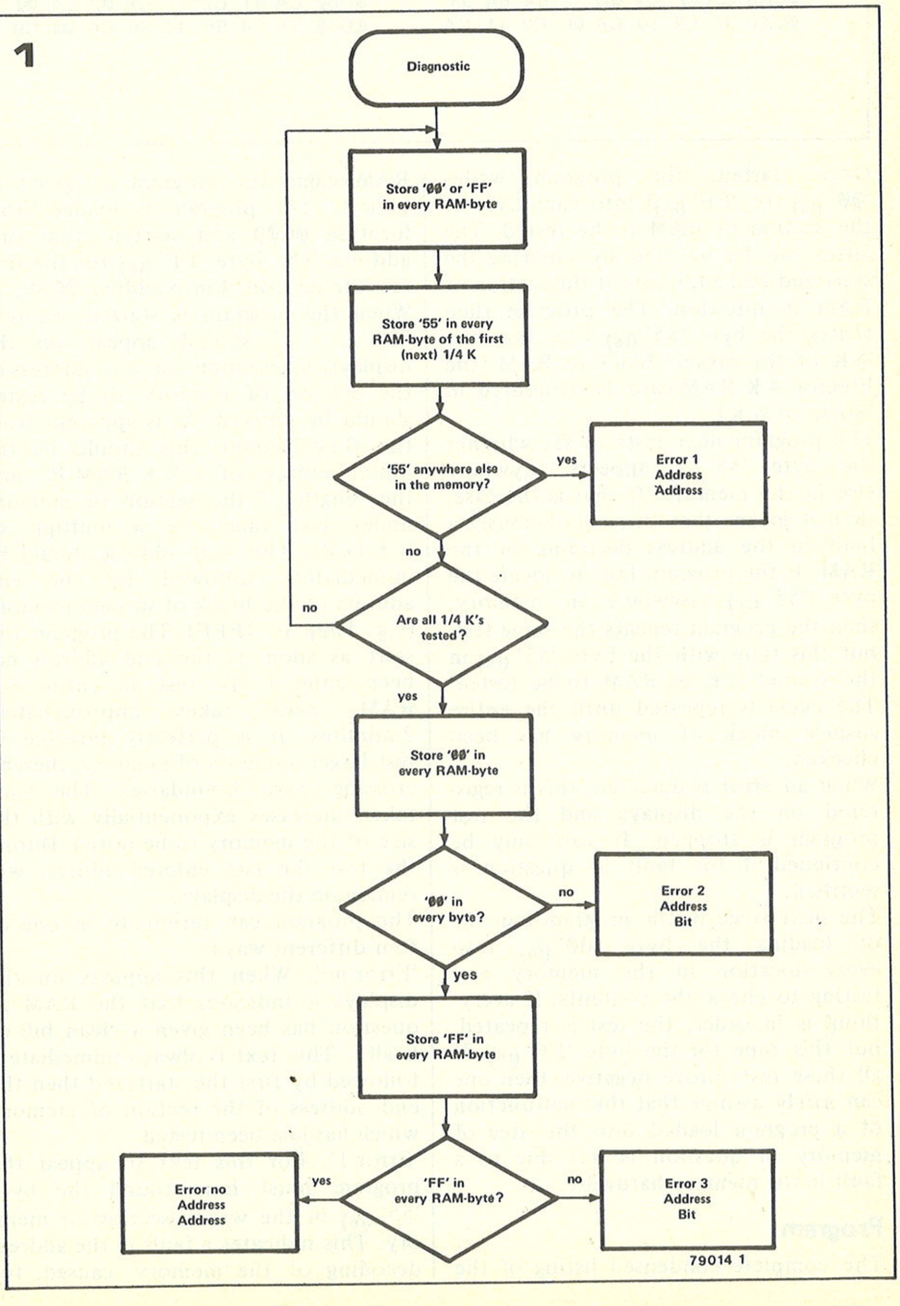


Figure 1. Flow diagram for the RAM-diagnostic program, showing the order of the different tests.

Table 1. For reasons of space, the program is listed in condensed form. The complete program is also recorded on the Elektor Software Service record ESS-001.

2

```
RAM – DG

0C00 C4 5E C9 06 C4 3D C9 05
0C08 C4 00 C9 FF C9 00 C4 80
0C10 C9 04 C9 03 C9 02 C9 01
0C18 C4 3E CA 1D C4 00 37 C4
0C20 55 33 3F C2 01 CA 0A CA
0C28 10 C2 02 CA 0B CA 11 3F
0C30 C2 01 CA 13 C2 02 CA 14
0C38 C4 00 CA 12 C2 10 CA 0E
0C40 C2 11 CA 0F C4 0D 37 C4
0C48 B4 33 3F C4 55 CA 12 C2
0C50 0A CA 0E C2 0B CA 0F C2
0C58 01 CA 13 C2 0B CA 14 C4
0C60 0D 37 C4 B4 33 3F C2 0E
0C68 E2 01 9C 08 C2 0F E2 02
0C70 9C 02 90 22 C2 01 CA 13
0C78 C2 02 CA 14 02 C2 0E F4
0C80 01 CA 0A CA 0C C2 0F F4
0C88 00 CA 0B CA 0D C4 0D 37
0C90 C4 DC 33 3F 90 A2 C4 00
0C98 CA 12 C2 10 CA 0E C2 11
0CA0 CA 0F C4 0D 37 C4 B4 33
0CA8 3F C2 10 CA 0C C2 11 CA
0CB0 0D C4 0D 37 C4 DC 33 3F
0CB8 C4 FF CA 12 C2 10 CA 0E
0CC0 C2 11 CA 0F C4 0D 37 C4
0CC8 B4 33 3F C2 10 CA 0C C2
0CD0 11 CA 0D C4 0D 37 C4 DC
0CD8 33 3F C2 01 CA 13 C2 02
0CE0 CA 14 C4 AA CA 12 90 1B
0CE8 C2 0C CA 10 C2 0D CA 11
0CF0 C2 12 E4 55 9C 0A C4 00
0CF8 CA 13 C2 0F CA 14 90 03
0D00 40 CA 14 C4 01 31 C4 07
0D08 35 C2 12 01 40 E4 AA 9C
0D10 0A C4 54 C9 00 C4 5C C9
0D18 FF 90 24 40 E4 55 9C 0A
0D20 C4 06 C9 00 C4 00 C9 FF
0D28 90 15 40 98 0A C4 4F C9
0D30 00 C4 00 C9 FF 90 08 C4
0D38 5B C9 00 C4 00 C9 FF C4
0D40 79 C9 06 C4 50 C9 05 C9
0D48 04 C9 02 C4 5C C9 03 C4
0D50 00 C9 01 C4 0E 37 C4 1C
0D58 33 3F C4 A0 CA 1D C2 10
0D60 CA 01 C2 11 CA 02 C4 00
0D68 37 C4 55 33 3F C4 00 C9
0D70 FF C9 00 C9 05 C9 06 C4
0D78 0E 37 C4 1C 33 3F C2 13
0D80 CA 01 C2 14 CA 02 C4 00
0D88 37 C4 55 33 3F C4 00 C9
0D90 FF C9 00 40 E4 AA 98 0B
0D98 40 E4 55 98 06 C4 00 C9
0DA0 01 C9 02 8F FF 8F FF C4
0DA8 0E 37 C4 1C 33 3F C4 0D
0DB0 37 C4 02 33 3F C2 0E 31
0DB8 C2 0F 35 C2 12 C9 00 C2
0DC0 0E E2 13 9C 06 C2 0F E2
0DC8 14 98 0F 02 C2 0E F4 01
0DD0 CA 0E C2 0F F4 00 CA 0F
0DD8 90 DB 3F 90 D8 C2 0C 31
0DE0 C2 0D 35 C1 00 E2 12 C9
0DE8 02 01 C2 12 E4 55 98 05
0DF0 40 98 0C 90 03 40 9C 07
0DF8 C4 0C 37 C4 E7 33 3F C2
0E00 0C E2 01 9C 09 C2 0D E2
0E08 02 9C 03 3F 90 CF 02 C2
0E10 0C F4 01 CA 0C C2 0D F4
0E18 00 CA 0D 90 C0 C4 08 C8
0E20 08 8F FF B8 04 9C FA 3F
0E28 00
```

Once started, the program writes '00'$_{(16)}$ (or 'FF'$_{(16)}$) into each byte of the section of RAM to be tested. The latter can be selected by entering the start and end addresses of the section of RAM in question. The program then writes the byte '55'$_{(16)}$ into the first ¼ K of the suspect block of RAM (the Elektor 4 K RAM card is structured in blocks of ¼ K).

The program next tests to see whether the byte '55'$_{(16)}$ appears anywhere else in the memory. If that is the case, then it means that there is obviously a fault in the address decoding of the RAM. If the program fails to locate the byte '55'$_{(16)}$ elsewhere in memory, then the program repeats the same test, but this time with the byte '55'$_{(16)}$ in the second ¼ K of RAM to be tested. The cycle is repeated until the entire suspect block of memory has been checked.

When an error *is* detected, this is registered on the displays and the test program is stopped. It can only be continued if the fault in question is rectified.

The next stage in the program consists of loading the byte '00'$_{(16)}$ into every location in the memory and testing to check the contents. If everything is in order, the test is repeated, but this time for the byte 'FF'$_{(16)}$. If all these tests prove negative, then one can safely assume that the malfunction of a program loaded into the area of memory in question is *not* due to a fault in the memory hardware.

Program

The complete condensed listing of the RAM-diagnostic program is given in table 1. The program is loaded from location 0C00 and started from that address. The byte 'FF'$_{(16)}$ for the first test can be loaded into address 0C39.

When the program is started the text 'DG . . . . . .' should appear on the displays, whereupon the start address of the section of memory to be tested should be entered. As is apparent from the flow-diagram, this should be the initial address of a ¼ K RAM IC, and the length of the section of memory under test must be a multiple of ¼ K (x 8). The start address should be immediately followed by the end address of the block of suspect memory (e.g. 1000 to 1FFF). The program will start as soon as the end address has been entered. To test an entire 4 K RAM card takes approximately 2 minutes. It is perfectly possible to test larger amounts of memory, thereby crossing page boundaries. The time taken increases exponentially with the size of the memory to be tested. During the test the last entered address will remain on the displays.

The program can terminate in one of four different ways:

'Error no'. When this appears on the displays it indicates that the RAM in question has been given a clean bill of health. This text is always immediately followed by first the start and then the end address of the section of memory which has just been tested.

'Error 1'. For this text to appear the program must have found the byte '55'$_{(16)}$ in the wrong section of memory. This indicates a fault in the address decoding of the memory, caused, for example, by a short in the $\overline{\text{CE}}$ line of the RAMs in question. This text is immediately followed by the 'block address' of the faulty ¼ K of RAM.

If the precise address of the faulty store is desired, this can be obtained by using the 'MODIFY' routine to load 'FF' into address 0C38 and then restarting the program. The exact address where the error is found will then be displayed immediately after the start and end addresses of the faulty 'block'.

'Error 2'. This text indicates that one or more bits have not been reset (loaded with '0'). The first address where this is the case is registered on the displays, followed by a two-digit number which indicates which bit(s) in the byte are false. For example, '0F' would mean that bits 0, 1, 2 and 3 of the byte in question contained a '1' instead of a '0'. Possible causes for such an error include a faulty RAM IC, bad solder joints, faulty IC sockets, a break in the $\overline{\text{CE}}$ or Read/Write lines.

'Error 3'. This is basically the same fault as in the previous case, except that here each bit is tested for a '1'. Once again the first address where a fault is detected is displayed.

In conclusion, it should be remarked that an 'Error' indication need not always denote a fault in the memory hardware. It is perfectly possible that the program will detect an 'error', which if the program is run a second time, will promptly disappear. In such a case the 'fault' is probably due to such factors as, e.g., unsatisfactory supply voltage(s), faulty decoupling capacitors or bus-drivers with too small a fan-out.

reading elektor

TUNs and TUPs

Nowadays, most low-frequency, small-signal silicon transistors from reputable manufacturers meet the following minimum specifications:

$U_{CEO, max}$	20 V
$I_{C, max}$	100 mA
$h_{fe, min}$	100
$P_{tot, max}$	100 mW
$f_{T, min}$	100 MHz

When a transistor of this type is required, it is referred to in Elektor as a **TUN** (Transistor, Universal, NPN) or a **TUP** (Transistor, Universal, PNP).

Some TUNs are the BC 107, BC 108 and BC 109 families, and the 2N3856A, 2N3859, 2N3860, 2N3904, 2N4124 and HEP S0011.

Some TUPs are the BC 177, BC 178 and BC 179 families, and the 2N2412, 2N3251, 2N3906, 2N4126, 2N4291 and HEP S0013.

DUS and DUG

Similarly, for many small-signal applications the only really important difference between all the available diodes is that some are silicon and some are germanium. When a general-purpose small-signal diode is required in an Elektor circuit, it is often designated **DUS** (Diode, Universal, Silicon) or **DUG** (Diode, Universal, Germanium). However, it should be noted that even a DUS or DUG should meet minimum specifications:

	DUS	DUG
$U_{R, max}$	25 V	20 V
$I_{F, max}$	100 mA	35 mA
$I_{R, max}$	1 μA	100 μA
$P_{tot, max}$	250 mW	250 mW
$C_{D, max}$	5 pF	10 pF

Some DUS's are: BA 127, BA 217, BA 218, BA 221, BA 222, BA 317, BA 318, BAX 13, BAY 61, 1N914 and 1N4148.

Some DUGs are: OA85, OA91, OA95 and AA116.

Resistors

Unless otherwise specified, resistors are ¼ Watt 5% tolerance carbon types. Higher power ratings are, of course, permissible (e.g. the recently introduced '⅓ Watt' types), provided they fit on the p.c. board — if this is to be used. A 10% tolerance type is usually also permissible, with only a minor effect on the performance.

The resistance values are specified using 'k' for 1000 Ω and 'M' for 1,000,000 Ω; the decimal point is replaced by either 'Ω', 'k' or 'M'.

For instance, 4Ω7 = 4.7 Ω; 4k7 = 4700 Ω; 4M7 = 4.7 MΩ.

Capacitors

The DC working voltage of capacitors (other than electrolytics) is normally assumed to be at least 60 V, unless otherwise specified. Generally speaking, of course, a DC working voltage equal to (or greater than) twice the supply voltage is sufficient. In most circuits where electrolytic capacitors are used, a working voltage equal to the supply voltage plus 20% is safe; very often, a lower voltage is sufficient. In recent Elektor circuits, the lowest DC working voltage permissible is often specified, regardless of availability; in practice, any higher voltage type can be used — bearing in mind that a higher voltage rating involves greater physical size, so the available space on the board should be watched. For instance, in a circuit operating off a 9 V battery, an elco might be specified as 1 μ/16 V — even though the normally available types are 1 μ/63 V.

Capacitor values are specified using 'p' for 10^{-12}, 'n' for 10^{-9} and 'μ' for 10^{-6}. As with resistors, the decimal point is replaced by one of these letters. This means that 4700 pF, for instance, is written as 4n7 — not as 0.0047 μF!

Voltages

The international letter symbol 'U' for voltage is normally used instead of the ambiguous 'V'. 'V' is normally reserved for 'volts'. For instance: U_b = 10 V, not V_b = 10 V.

The DC test voltages shown in circuits are measured with a 20 kΩ/V instrument, unless otherwise specified.

No mains (power line) voltages are given in Elektor circuits. It is assumed that our readers know what voltage is standard in their part of the world!

International problems

Although it is the intention that Elektor circuits can be built and used all over the world, some problems are unavoidable.

Readers in countries that use 60 Hz should note that Elektor circuits are designed for 50 Hz operation. This will not normally be a problem; however, in cases where the mains frequency is used for synchronisation some modification may be required. In some cases, the necessary modifications are given; in others, especially where modification involves drastic re-design, the circuit idea may be of use — even though the circuit itself is not.

Circuits intended for use with domestic television receivers may also run into difficulties. As many of our readers will know, 'Television Standards' are anything but 'standard'! However, by avoiding sound and colour wherever possible, a reasonable degree of international compatibility can be achieved — provided the preset adjustments are given a sufficiently wide range.

Finally, especially for our readers in Canada and the USA, a list of equivalents for some of the commonly-used transistor types may prove useful:

AF 239: G0003
BC 140, BC 141, BC 142: S3011
BC 160: S3012
BC 546: no direct equivalent known to us, however in most cases an S0024 can be used
BD 241: TIP29, S5000
BD 242: TIP30, S5006
BF 259, BF 494, BFT 66: no direct equivalent known to us; basically, these are low-voltage, low-current high-frequency devices.

Some further equivalents differ only in that the emitter and collector connections are transposed, so that they must be mounted 'back-to-front' on the EPS p.c. boards:

TUN: RS2010, RS2016
TUP: RS2022, RS2034
BC 107 or equ.: S0015
BC 177 or equ.: S0019
BC 109B,C or equ.: S0024
BC 517: S9100
BC 556: S0026

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TUPTUNDUGDUS

Wherever possible in Elektor circuits, transistors and diodes are simply marked 'TUP' (Transistors, Universal PNP), 'TUN' (Transistor, Universel NPN), 'DUG' (Diode, Universal Germanium) or 'DUS' (Diode, Universal Silicon). This indicates that a large group of similar devices can be used, provided they meet the minimum specifications listed in tables 1a and 1b.

	type	U_{ceo} max	I_c max	hfe min.	P_{tot} max	f_T min.
TUN	NPN	20 V	100 mA	100	100 mW	100 MHz
TUP	PNP	20 V	100 mA	100	100 mW	100 MHz

Table 1a. Minimum specifications for TUP and TUN.

Table 1b. Minimum specifications for DUS and DUG.

	type	U_R max	I_F max	I_R max	P_{tot} max	C_D max
DUS	Si	25 V	100 mA	1 μA	250 mW	5 pF
DUG	Ge	20 V	35 mA	100 μA	250 mW	10 pF

Table 2. Various transistor types that meet the TUN specifications.

TUN		
BC 107	BC 208	BC 384
BC 108	BC 209	BC 407
BC 109	BC 237	BC 408
BC 147	BC 238	BC 409
BC 148	BC 239	BC 413
BC 149	BC 317	BC 414
BC 171	BC 318	BC 547
BC 172	BC 319	BC 548
BC 173	BC 347	BC 549
BC 182	BC 348	BC 582
BC 183	BC 349	BC 583
BC 184	BC 382	BC 584
BC 207	BC 383	

Table 3. Various transistor types that meet the TUP specifications.

TUP		
BC 157	BC 253	BC 352
BC 158	BC 261	BC 415
BC 177	BC 262	BC 416
BC 178	BC 263	BC 417
BC 204	BC 307	BC 418
BC 205	BC 308	BC 419
BC 206	BC 309	BC 512
BC 212	BC 320	BC 513
BC 213	BC 321	BC 514
BC 214	BC 322	BC 557
BC 251	BC 350	BC 558
BC 252	BC 351	BC 559

The letters after the type number denote the current gain:

A: α' (β, h_{fe}) = 125-260
B: α' = 240-500
C: α' = 450-900.

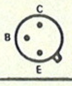
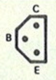
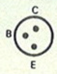
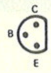
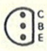
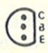
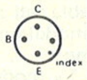
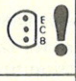
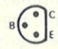
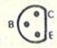
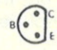
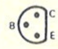
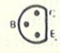
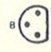
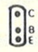
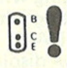
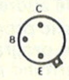
Table 4. Various diodes that meet the DUS or DUG specifications.

DUS		DUG
BA 127	BA 318	OA 85
BA 217	BAX13	OA 91
BA 218	BAY61	OA 95
BA 221	1N914	AA 116
BA 222	1N4148	
BA 317		

Table 5. Minimum specifications for the BC107, -108, -109 and BC177, -178, -179 families (according to the Pro-Electron standard). Note that the BC179 does not necessarily meet the TUP specification ($I_{c,max}$ = 50 mA).

	NPN	PNP
	BC 107 BC 108 BC 109	BC 177 BC 178 BC 179
U_{ceo} max	45 V 20 V 20 V	45 V 25 V 20 V
U_{ebo} max	6 V 5 V 5 V	5 V 5 V 5 V
I_c max	100 mA 100 mA 100 mA	100 mA 100 mA 50 mA
$P_{tot.}$ max	300 mW 300 mW 300 mW	300 mW 300 mW 300 mW
f_T min.	150 MHz 150 MHz 150 MHz	130 MHz 130 MHz 130 MHz
F max	10 dB 10 dB 4 dB	10 dB 10 dB 4 dB

Table 6. Various equivalents for the BC107, -108, . . . families. The data are those given by the Pro-Electron standard; individual manufacturers will sometimes give better specifications for their own products.

NPN	PNP	Case	Remarks
BC 107 BC 108 BC 109	BC 177 BC 178 BC 179		
BC 147 BC 148 BC 149	BC 157 BC 158 BC 159		P_{max} = 250 mW
BC 207 BC 208 BC 209	BC 204 BC 205 BC 206		
BC 237 BC 238 BC 239	BC 307 BC 308 BC 309		
BC 317 BC 318 BC 319	BC 320 BC 321 BC 322		I_{cmax} = 150 mA
BC 347 BC 348 BC 349	BC 350 BC 351 BC 352		
BC 407 BC 408 BC 409	BC 417 BC 418 BC 419		P_{max} = 250 mW
BC 547 BC 548 BC 549	BC 557 BC 558 BC 559		P_{max} = 500 mW
BC 167 BC 168 BC 169	BC 257 BC 258 BC 259		169/259 I_{cmax} = 50 mA
BC 171 BC 172 BC 173	BC 251 BC 252 BC 253		251 . . . 253 low noise
BC 182 BC 183 BC 184	BC 212 BC 213 BC 214		I_{cmax} = 200 mA
BC 582 BC 583 BC 584	BC 512 BC 513 BC 514		I_{cmax} = 200 mA
BC 414 BC 414 BC 414	BC 416 BC 416 BC 416		low noise
BC 413 BC 413	BC 415 BC 415		low noise
BC 382 BC 383 BC 384			
BC 437 BC 438 BC 439			P_{max} = 220 mW
BC 467 BC 468 BC 469			P_{max} = 220 mW
	BC 261 BC 262 BC 263		low noise

variable fuzz-box

A simple circuit for musical sound effects

Particularly in modern pop music, electronically-produced sound effects are an extremely common device. One only has to think, for example, of the widespread use of the 'wa-wa' pedal and the fuzz-box. With this in mind, Elektor have designed a super simple circuit which, by employing signal clipping techniques, can produce a large variety of manually controlled sound effects.

Using only a handful of components it is possible to construct a highly effective variant of the well-known fuzz box. This type of circuit commonly employs a pair of anti-parallel connected diodes, which are inserted in the amplifier (be it IC — or transistorised) so as to clamp the output signal above certain values of the input signal. This process is illustrated in figure 1, where for the sake of clarity the amplifier is assumed to have unity gain over the linear portion of its transfer characteristic. As can be seen, above an input voltage U_1, the output voltage shows no further increase; similarly, the output voltage will not fall below the input value $-U_2$. If U_1 is equal to U_2 (which is typically the case in fuzz-box circuits) and the input signal is sufficiently large, then the input and output signals will differ from one another as shown in figure 1b.

When, as is the case in figure 1b, the output signal clips *symmetrically* (i.e. $U_1 = U_2$), it contains only *even* harmonics, and it is this which gives the

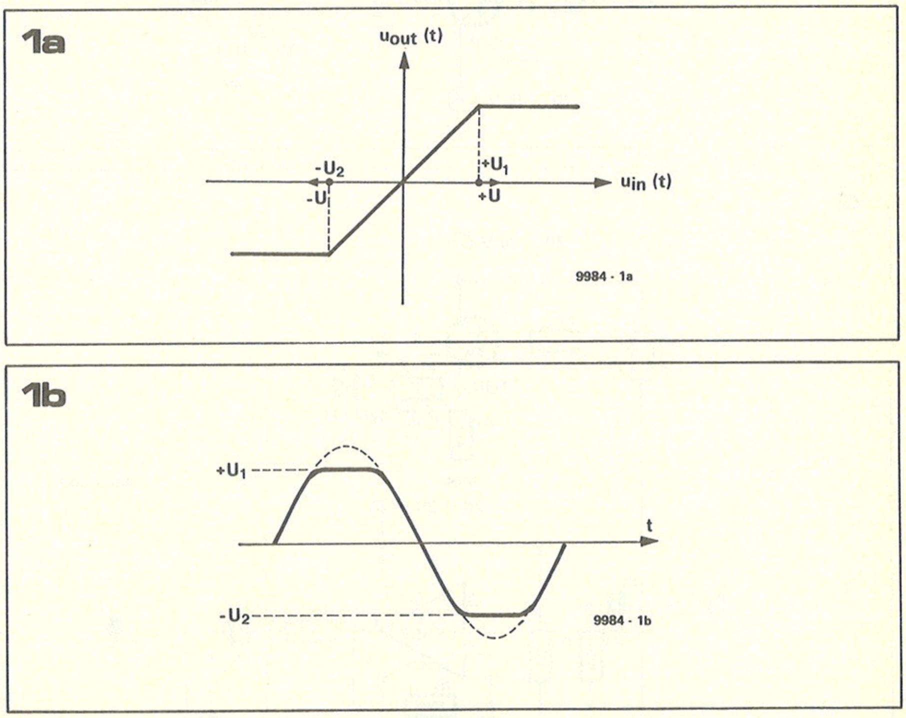


Figure 1. The response of an amplifier which is driven into 'hard' clipping (a) and the corresponding input and output waveforms.

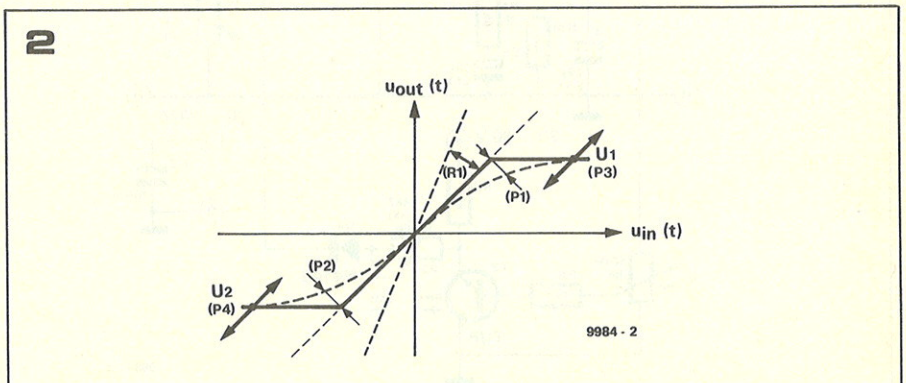
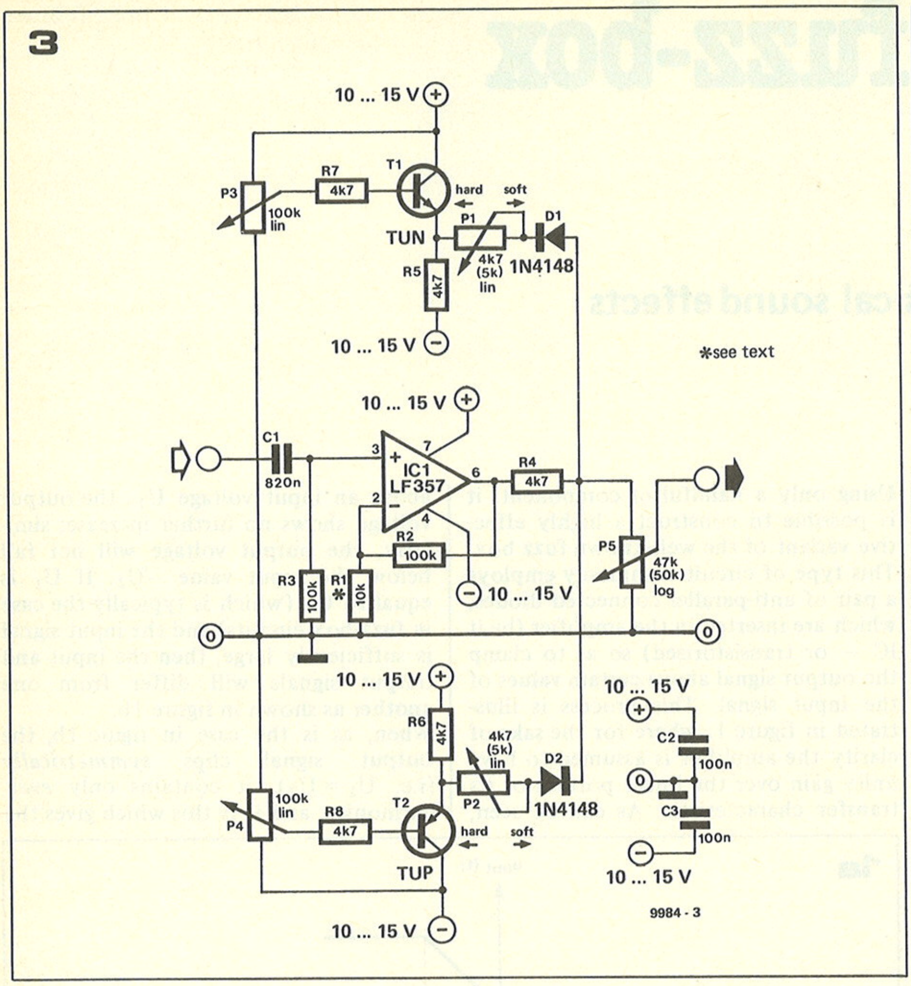


Figure 2. There are five parameters of the clipping response of an amplifier which can be independently varied.



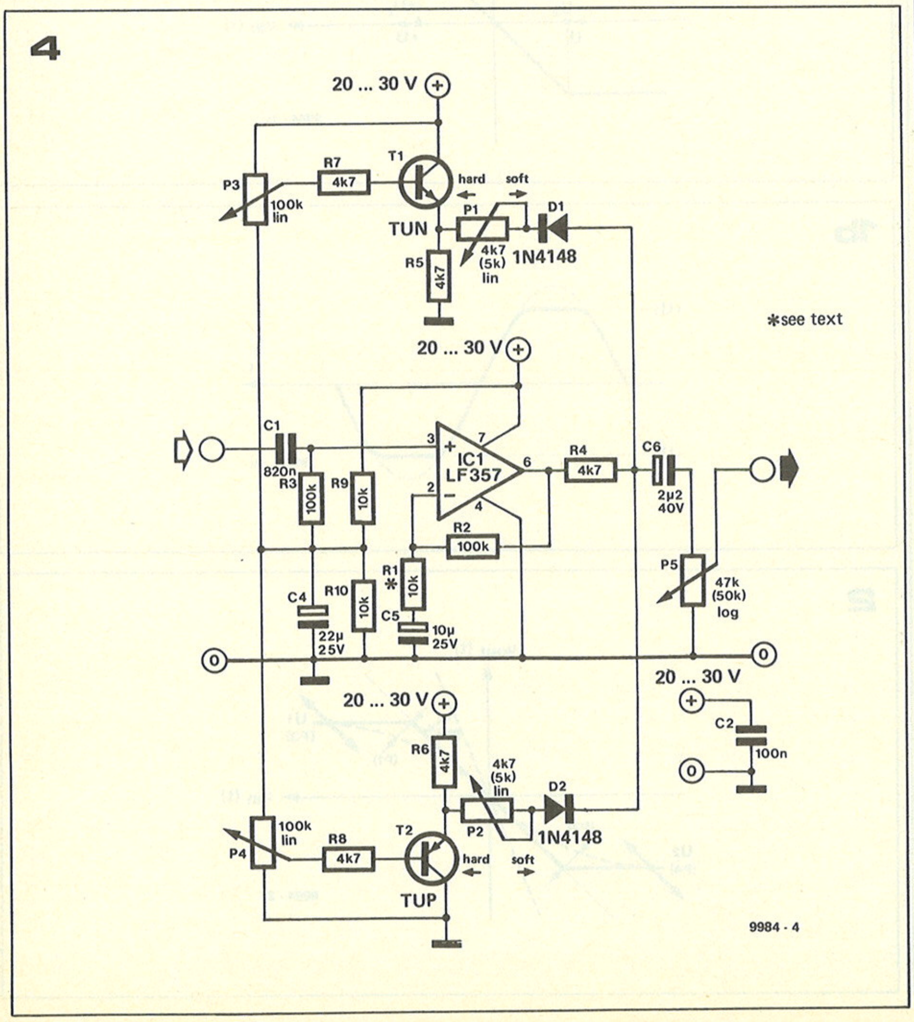


Figure 3. The circuit diagram of a variable fuzz-box for a symmetrical power supply.

Figure 4. The circuit of a variable fuzz-box for an asymmetrical power supply.

Figure 5. Example of a suitable power supply for the circuit of figure 3 (a) and of figure 4 (b).

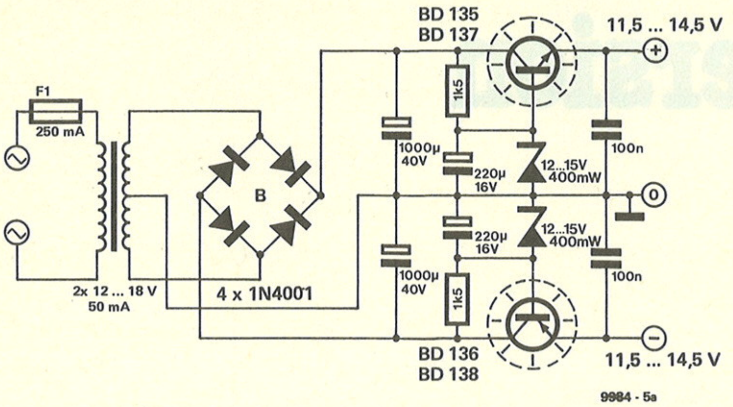
resultant musical signal its characteristically rough and 'fuzzy' edge. However the tonal character of the music signal can be considerably enriched by arranging that the output signal clips *asymmetrically* (i.e. $U_1 \neq U_2$). In this way it is possible to influence the sound of the fuzz-box to produce more varied effects. The circuit described here is designed to offer the best of both worlds by allowing the clipping levels U_1 and U_2 to be altered independently of one another, thus permitting the type of effect to be varied as desired.

Varying the clipping levels is not, however, the only way of influencing the sound of the (clipped) output signal. A further factor determining the type of effect produced is whether the amplifier starts clipping almost immediately it reaches a particular level (hard clipping), or whether the transition between non-limiting and limiting is more gradual (soft clipping). In the circuit described here it is possible to continuously vary the response of the amplifier between these two extremes. The various control facilities offered by the 'variable fuzz-box' are illustrated in figure 2.

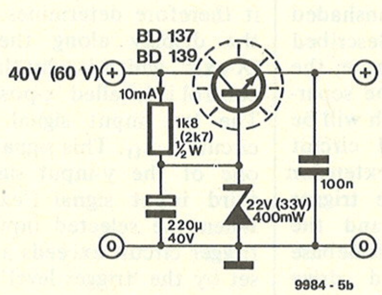
Circuit diagram

The complete circuit diagram of the fuzz-box is shown in figures 3 and 4; figure 3 gives the circuit for a symmetrical power supply (plus, minus and earth), whilst figure 4 is designed for an

5a



5b



asymmetrical supply (plus and minus/ earth). The current consumption of the circuit is 10 to 15 mA, whilst in both figures 3 and 4 the input impedance is 100 k.

The operation of the circuit is fairly straightforward. The input signal is first amplified by IC1, the gain of which is $1 + \frac{R2}{R1}$. The gain can be altered by varying R1; with the value given the gain is 11. The output signal of IC1 is fed via R4 (and C6 in figure 4) to the volume control P5, the wiper voltage of which forms the output signal of the circuit.

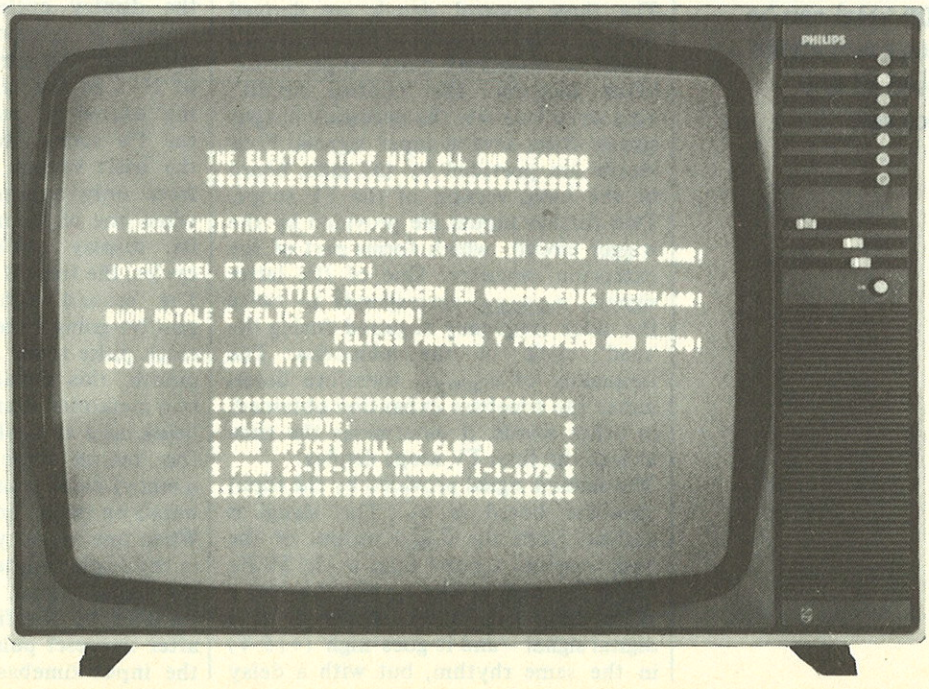
The clipping is controlled as follows: as soon as the voltage at the right hand end of R4 exceeds the wiper voltage of P3 (or falls below the wiper voltage of P4) the output signal is attenuated. The degree of attenuation is determined by the ratio of R4 to P1 (P2). With P1 (P2) set to its minimum resistance value the output signal is completely attenuated, i.e. is 'hard' clipped. With P1 set to its other end stop (minimum resistance) 'soft' clipping is obtained. Thus by adjusting the four potentiometers P1 ... P4 which control both the levels at which the amplifier starts to clip and the degree of clipping, it is possible to vary the tonal character of the resultant sound as desired.

As far as a power supply is concerned, various possibilities exist. Figures 5a and 5b show a suitable arrangement for the circuits of figures 3 and 4 respectively.

Other applications

Apart from its use as a variable special effects generator the circuit also has other possible applications. For example, it can be used to limit the input signal of a power amplifier to the value which just produces maximum output. In this way one obviates the danger of current limiting or clipping occurring in the power amp and its undesirable consequences for the listener. At the same time the circuit thus represents a type of overload protection for the power amp.

Another interesting idea would be to use the circuit in conjunction with P.A. systems. There are various theories which claim that it is possible to increase the volume of the signal by clipping it in a certain way. The increase in the harmonic content of the signal is said not to impair the intelligibility of the address. It has also been suggested that different clipping characteristics may explain some of the oft-debated differences between 'transistor-sound' and 'valve-sound'. The circuit described here seems ideally suited to test the truth of these ideas. However readers wishing to experiment in this field would do well to spare a thought for their neighbours!



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          THE ELEKTOR STAFF WISH ALL OUR READERS
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A MERRY CHRISTMAS AND A HAPPY NEW YEAR!
                 FROHE WEIHNACHTEN UND EIN GUTES NEUES JAHR!
JOYEUX NOEL ET BONNE ANNEE!
               PRETTIGE KERSTDAGEN EN VOORSPOEDIG NIEUWJAAR!
BUON NATALE E FELICE ANNO NUOVO!
                       FELICES PASCUAS Y PROSPERO ANO NUEVO!
GOD JUL OCH GOTT NYTT AR!

           $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
           $ PLEASE NOTE:                     $
           $ OUR OFFICES WILL BE CLOSED       $
           $ FROM 23-12-1978 THROUGH 1-1-1979 $
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TV scope - extended version

The TV scope, introduced in the recent October issue, can now be completed. Two months ago the basic version was described in detail and the necessary circuits were given for converting a standard domestic television receiver into an oscilloscope — be it with limited capabilities. Last month the possibilities for extending the TV scope were discussed; in particular, the principles and advantages of a variable timebase and trigger facilities were explained. This third and final article in the series gives the necessary extension circuits.

Although the basic version is an extremely useful tool when testing low-frequency circuits, its 'big brother' offers vastly superior display possibilities. Any signal within the frequency range of the scope (DC to 100 kHz) can be displayed as a clear and stable trace on the screen of any domestic TV receiver.

Several block diagrams can be given for the same circuit, as shown in figure 1: the third (and last!) block diagram of the 'TV scope - extended version'. The sections required for extending the TV scope are shaded in; the unshaded portions are the basic version described in the October issue. Furthermore, the block diagram clearly shows the separate portions of the circuit which will be mounted on separate printed circuit boards. In the following, these extension circuits will be discussed: the trigger circuit, the input timebase and the 'bucket-brigade memory' timebase expander with its associated drive circuits. The portions of the diagram shown in dotted lines are only required for a two-channel version of the 'scope'.

The timebase expanders (bucket-brigade memories) of the A- and B-channels (assuming that the latter is also included) 'slow down' the analogue input signals u_{ya} and u_{yb} as required. For correct operation, they require three control signals: two clock signals, $\phi 1$ and $\phi 2$, and a 'mode' signal (u_m) that determines which of the memories is in the 'read' cycle and which is in the 'display' mode. The basic principles involved were described last month.

The three control signals are derived from a fairly complicated logical circuit, which is designated quite simply in the block diagram: the 'control circuit'. This circuit derives the necessary output signals from several input signals. Four inputs are provided by the main board of the basic version of the TV scope. Two further inputs are provided by the trigger circuit, which forms part of the extension circuitry. One of the latter signals, u_{sample}, corresponds to twice the clock frequency required during the 'read' cycle of the memories. The frequency of u_{sample} therefore determines the timebase expansion obtained; in other words, it determines the time axis of the final TV scope display.

The second signal provided by the input timebase board is u_x. This signal is derived from the $\overline{u_{reset}}$ output of the basic version: a pulse train at the 50 Hz frame frequency. The u_x signal is also a pulse train — in other words, it is a digital signal — and it goes 'high' (+15 V) in the same rhythm, but with a delay with respect to $\overline{u_{reset}}$ that is determined by the setting of a potentiometer, 'x-pos'. The u_x signal determines the start of the display cycle with respect to the start of each frame of the TV picture. In effect, it therefore determines the position of the display along the time axis or 'X-axis', which is why the corresponding control is labelled 'x-pos(ition)'.

The last input signal to the control circuit is u_{tr}. This signal is derived from one of the y-input signals or from a third input signal ('external trigger'). When the selected input signal to the trigger circuit exceeds a certain level, as set by the 'trigger level' control, the u_{tr} output goes 'high' — see figure 2. Since the positive-going edge is detected by the control circuit, triggering occurs on the leading edge of the selected input signal. Basically, this circuit is equivalent to similar circuits in any 'normal' oscilloscope.

Figure 3 shows the relationships between the various in- and output signals of the control circuit. At each reset pulse, the mode signal (u_m) changes state, selecting first one memory and then the other for each channel. Simultaneously the u_x signal goes low for a fixed period; at the end of this period the display cycle starts. Two things happen at this point. The signal u_{gate} goes high; this signal is fed to one input of N15 in the circuit which generates the white-level pulses for the trace on the TV screen (see the description of the basic version, figure 4c), so that a trace only appears on the TV screen when one of the memories is actually in its display cycle. Between display cycles, the trace is blanked.

The second signal initiated by the positive-going edge of u_x is the display clock pulse train. As explained last mon month, this signal must be fed to the two memories alternately — each in turn being used as display memory — and for this reason these (relatively low frequency) clock pulses appear in alternate bursts on the $\phi 1$ and $\phi 2$ lines.

When one memory (for each channel) is in the display mode, the other is 'storing' the input signal. This 'read' cycle is initiated by the first trigger pulse, u_{tr}, after the reset pulse. A control signal to the input timebase, u_{et} ('enable timebase'), goes positive. The input timebase clock generator starts on the positive-going edge of u_{et} and produces a rapid burst of clock pulses, alternately on the Ø1 and Ø2 lines. As in a conventional scope, this facility is included in order to obtain a stable display – independent of input frequency.

Having surveyed the basic principles involved, it is now time to discuss the necessary circuits in greater detail.

Trigger circuit

The trigger circuit is shown in figure 4. A three-way switch selects the desired trigger input: either of the two input signals to the TV scope, or an independent trigger input. If either of the two Y-inputs to the scope is selected, a signal at 'standard level' is required. This signal, u_t, is derived from the input amplifier(s) of the TV scope – see 'TV scope - basic version', figure 2 on page 10-31.

Depending on the type of signal selected, either AC or DC coupling may give better results. Switch S2, bridging C1, is used to select the desired option. IC1 boosts the input signal to a level suitable for the comparator stage, IC2. This comparator refers the input signal level to a DC voltage set by the 'trigger level' potentiometer. If the (amplified) input signal exceeds the preset level, the output of IC2 goes high (see figure 2) – note that IC1 inverts the input signal!

As long as trigger pulses are appearing at regular intervals, LED D2 lights ('trig'd). The output signal, u_{tr}, is fed to the control circuit on the memory board.

The printed circuit board for the trigger circuit contains one further control: potentiometer P2, 'trace distance'. This control has nothing to do with the trigger circuit, but it happened to fit neatly at this point on the front panel. The function of this control will be described further on.

The trigger circuit and the trace distance control are both mounted on the board shown in figure 5. The 'AC/DC' switch S2 and capacitor C1 are mounted off-board. Basically, of course, any LED can be used for D2. However, the neatest

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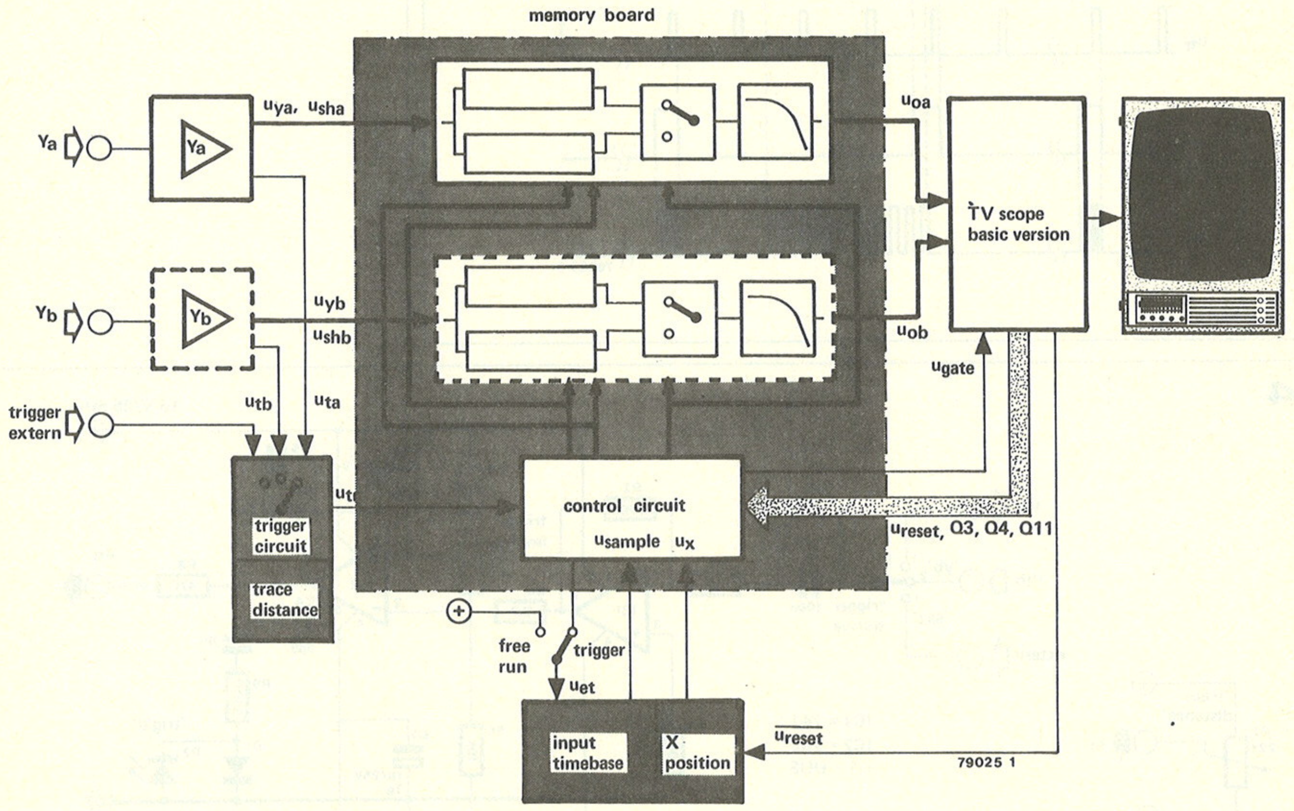

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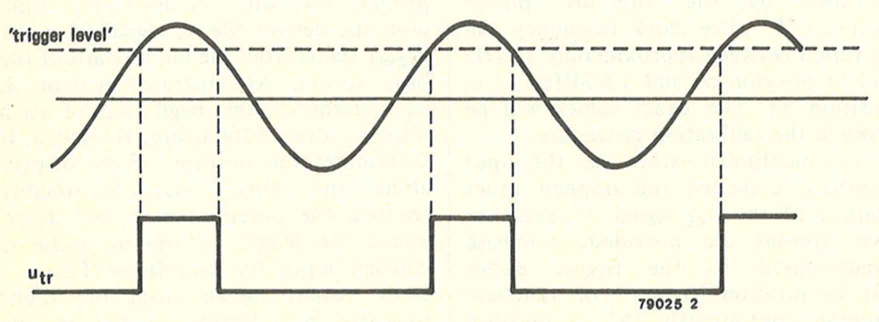


Figure 1. Block diagram of the TV scope – extended version. The shaded sections are the extension circuits.

Figure 2. Trigger pulses (u_{tr}) occur when the 'trigger source' signal exceeds the 'trigger level'.

3

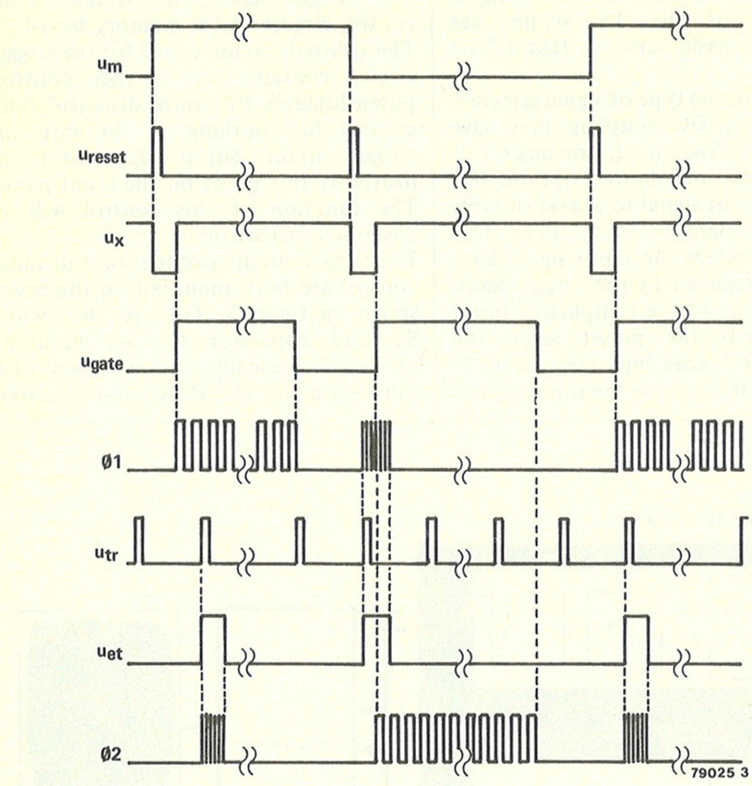


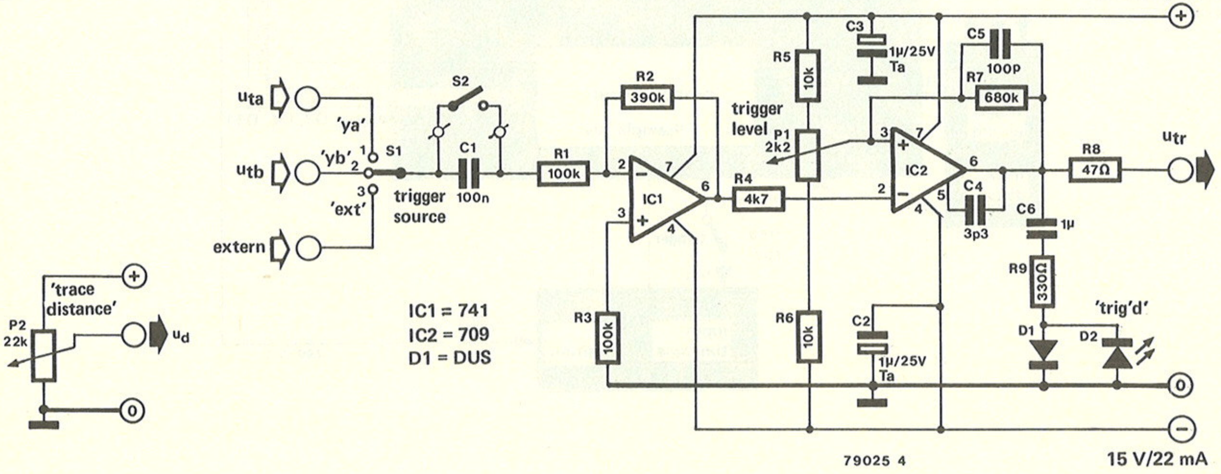
Figure 3. The relationships between the various in- and output signals of the control circuit.

Figure 4. The trigger circuit, which derives the u_{tr} pulses from the analogue 'trigger source' input. The corresponding printed circuit board also contains the 'trace distance' control, P2, since it happens to fit neatly at this point on the front panel.

Figure 5. The 'trigger board' (EPS 9969-2). All components shown in figure 4, with the exception of S2 and C1, are mounted on this board; the miniature LED, D2, is mounted on the copper side of the board.

Figure 6. The input timebase is a CMOS square-wave generator; the frequency is determined by a selector switch and a fine frequency control. The remaining gate in the same IC, N4, is used to derive the u_x pulses from the u_{reset} signal.

4



result is obtained if a 3 mm Ø green LED is used; if it is mounted on the copper side of the board it will fit in the corresponding hole in the front panel.

Input timebase

The input timebase is the generator for the input clock signal, u_{sample}. The frequency of this signal determines the sampling rate of the input signal(s) to the TV scope. As described earlier, u_{sample} is a square-wave signal at twice the frequency required for sampling and storing the input signal(s).

The circuit of the input timebase is given in figure 6. The upper portion of this diagram is the clock generator proper. This is a CMOS multivibrator, the frequency of which can be selected by means of the six-way switch S2; fine control of the output frequency is provided by the 'time/div' potentiometer, P1. The clock frequency can be varied between approximately 32 kHz (S2 in position 6) and 1.6 MHz (S2 in position 1). The exact values will be given in the calibration procedure.

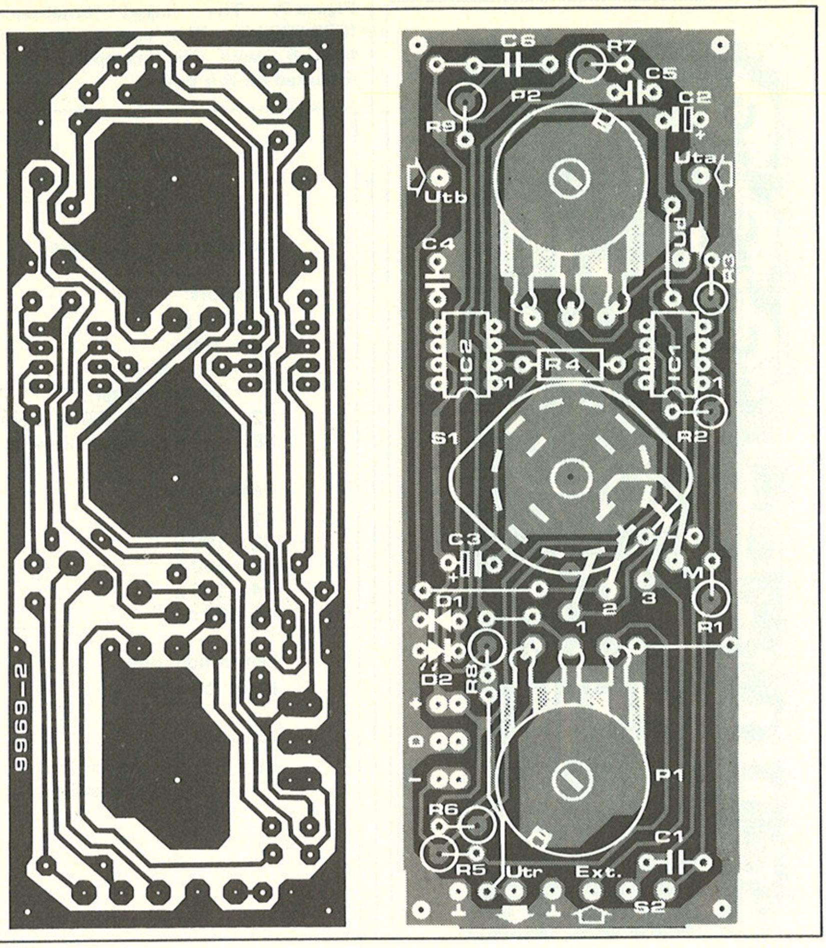
It was mentioned earlier that the input timebase is started and stopped under control of the u_{et} signal. In practice, two options are provided: timebase synchronised to the trigger pulses (S1 in position 'trigger') or timebase running continuously (S1 in position 'free run').

As in the case of the trigger circuit, the 'input timebase' printed circuit board actually contains a further circuit that has nothing to do with the timebase proper. N4, with its associated components, derives the u_x signal from the $\overline{u_{reset}}$ signal from the main board of the basic version. As illustrated in figure 3, u_x determines the beginning of each display cycle. Effectively, therefore, it determines the position of the display along the 'time' axis. Reasonably enough, the potentiometer that determines the length of the u_x pulse is labelled 'x-pos' for 'x-position' (P8).

Both output signals from the input timebase p.c. board are fed to the 'memory board'.

A printed circuit board and component

5



Parts list trigger circuit

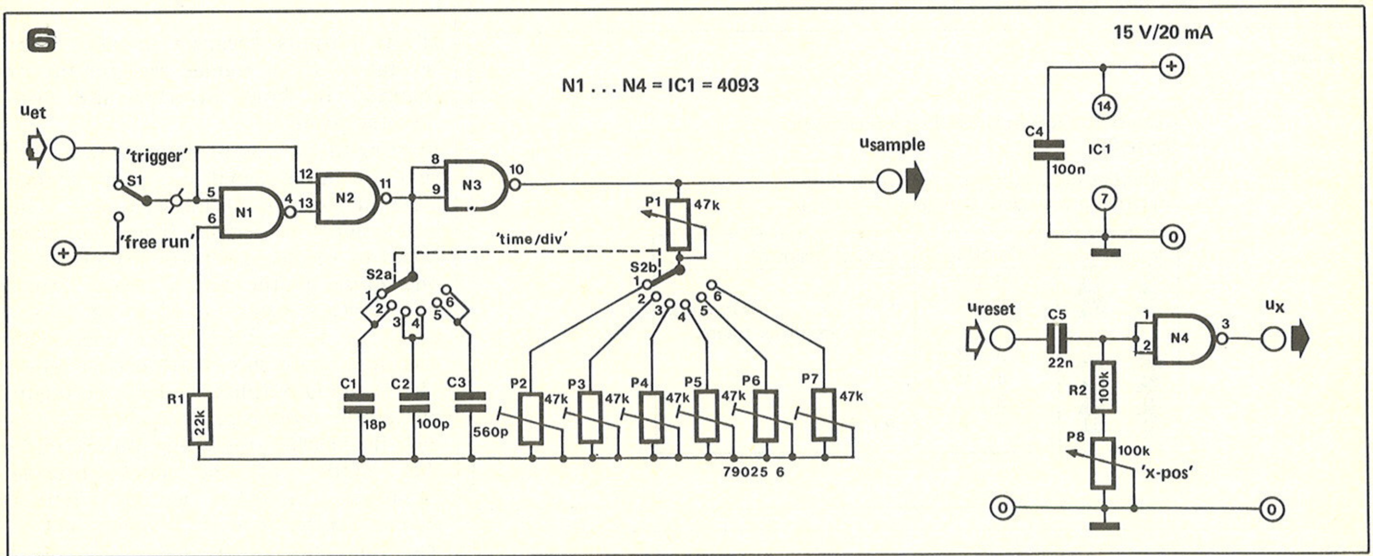
Resistors:
R1,R3 = 100 k
R2 = 390 k
R4 = 4k7
R5,R6 = 10 k
R7 = 680 k
R8 = 47 Ω
R9 = 330 Ω
P1 = 2k2 (2k5) lin potentiometer
P2 = 22 k (25 k) lin potentiometer

Capacitors:
C1 = 100 n
C2,C3 = 1 μ/25 V tantalum
C4 = 3p3
C5 = 100 p
C6 = 1 μ

Semiconductors:
IC1 = 741
IC2 = 709
D1 = DUS
D2 = LED (3 mm, green)

Sundries:
S1 = 1-pole, 3-way switch
S2 = single-pole, single-throw switch

6



layout for the input timebase and x-position circuit are given in figure 7. Switch S1 is mounted off-board. The adjustment procedure for the six preset potentiometers will be described later. Meanwhile, as with almost any other circuit, it is advisable to set all presets to the mid-position for the time being.

Memory board

It was already fairly clear from the block diagram shown in figure 1: most of the extension circuits for the TV scope are contained on one board. The 'memory board'. Two circuits are mounted on this p.c. board: the control circuit (figure 8a) for the memories, and the bucket-brigade memories with their associated circuitry (figure 8b).

The control circuit is a fairly straightforward logic circuit using CMOS ICs. Like most logic circuits (and in contrast to most analogue circuits) it receives a multitude of input signals and produces a similar plethora of outputs. From the main board (basic version) it receives three timing signals, Q_3, Q_4 and Q_{11}, and u_{reset} (both in normal and in inverted format); the input timebase provides both u_x and u_{sample}, determining the start of the display and the sample-rate of the store cycles, respectively; finally, the trigger circuit provides a signal, u_{tr}, which determines the start of the store cycle.

From these input signals, the control circuit derives several output signals. The clock signals for the bucket-brigade memories, $\emptyset 1$ and $\emptyset 2$, both non-inverted and inverted ($\overline{\emptyset 1}$ and $\overline{\emptyset 2}$) and the mode signal, u_m, plus its inverted form ($\overline{u_m}$). In addition to these six control signals for the memories, two further outputs must be obtained: u_{gate}, which controls the white-level pulse gate on the main board, as described earlier; and u_{et}, which enables the clock generator on the input timebase board.

Operation of this part of the extension circuit can be considerably simplified by referring to the pulse diagram shown in figure 3. This diagram shows the required relationships between half the input signals to the control circuit and

7

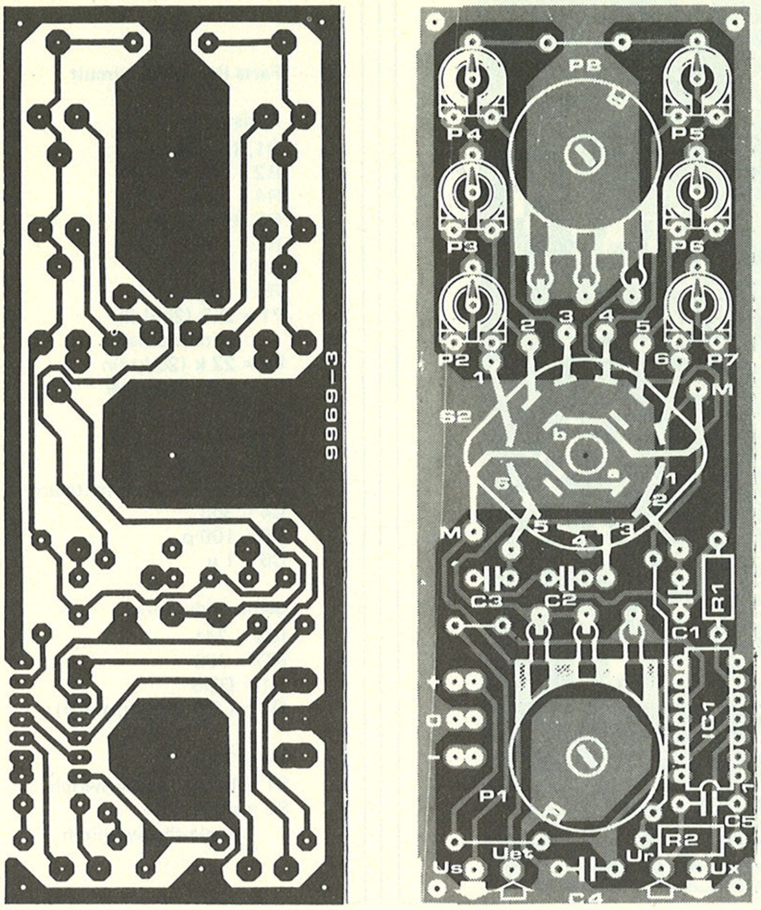


Figure 7. The 'input timebase board' (EPS 9969-3). The components shown in figure 6, with the exception of S1, are mounted on this board.

Parts list input timebase

Resistors:
R1 = 22 k
R2 = 100 k
P1 = 47 k (50 k) lin
potentiometer
P2 . . . P7 = 47 k (50 k) preset
P8 = 100 k lin potentiometer

Capacitors:
C1 = 18 p
C2 = 100 p
C3 = 560 p
C4 = 100 n
C5 = 22 n

Semiconductors:
IC1 = CD 4093

Sundries:
S1 = 1-pole, 2-way switch
S2 = 2-pole, 6-way switch

Table 1

DC test voltages at the points indicated in figure 8b

Note that these voltages apply after initial adjustment has been completed — see text.

test point	DC voltage	set by means of
①, ①'	5.5 V	
②, ②'	5.5 V	P4 on the corresponding input amplifier board
③, ③'	3 V	
④, ④'	3 V	
⑤, ⑤'	−3 V	
⑥, ⑥'	4 V	P2, P2'

Table 2

Modifications to the basic version

circuit	board no.	figure no. s	component	original value	new value
input amplifier	9968-1	2 & 3, pages 10-31 & 10-32	R10	22 k	5k6
			R23	220 k	2M2
main board	9968-2	4c & 6, pages 10-33 & 10-34	R7	470 Ω	220 Ω
			remove the wire link marked between u_g and +		

all its outputs (bearing in mind that several of these signals are present or required in both inverted and non-inverted form).

Starting at the top of figure 3, it is clear that the mode signal, u_m, must change state at each reset pulse, u_{reset}. The latter signal is derived from the main board of the basic version; it consists of one pulse at the end of each frame period. This signal is fed to the clock input of FF1. Each reset pulse will therefore cause this flip-flop to 'toggle'. The Q and $\overline{Q}$ outputs of FF1 are brought out as the mode signals u_m and $\overline{u_m}$; as described earlier, these signals determine the 'mode' of the bucket-brigade memories — in other words, whether they are in the 'read' or 'display' cycle.

The following signals shown in figure 3 are related to the 'display' cycle. When u_x goes positive (the delay with respect to the u_{reset} pulse being determined by the setting of the 'x-pos' potentiometer on the input timebase board) the display cycle must start. To understand the operation of the control circuit during this cycle, we must first side-track briefly and consider the control signals Q_3 and Q_4 and the function of IC5.

IC5 (and IC3, of which more later) is a 14-bit binary counter. Only 8 bits are actually used in this circuit, the output being taken from the Q_9 pin, so that the maximum count corresponds to 256 clock pulses. These pulses are derived, via N9 and S1, from either the Q_3 or the Q_4 output of the main board.

Table 3
Interconnections between boards for the extended version

insulated wire

signal/ voltage	from	to	remarks
u_{sync}	main board	video mixer	
u_{cal}			
u_w			
u_{tb}/u_f	main board	main board	wire link on main board
u_x	input timebase	memory board	
u_{sample}			
$\overline{u_{reset}}$	main board	input timebase	
$\overline{u_{reset}}$	main board	memory board	
u_{gate}	main board	memory board	
u_{reset}			
Q_{11}			
u_{et}	input timebase	'free run' switch	
u_{et}	'free run' switch	memory board	
0 V	all boards		
0 V	video mixer	LED D3	
0 V	mains trafo	supply	case connected to supply common
+15 V	all boards		note R_a, R_b, C_a, C_b
+15 V	video mixer	LED D3	via R7
+15 V	input timebase	'free run' switch	
−15 V	all boards, with exception of TV modulator		
2 x 18 V	mains trafo	supply board	
mains connection	mains input	transformer	via fuse and mains switch, twisted

screened cable

signal	from	to	remarks
u_{ia}	y_a input	y_a input amplifier	via AC/DC switch
u_{ib}	y_b input	y_b input amplifier	via AC/DC switch
u_{ya}	y_a input amplifier	memory board	
u_{sha}			
u_{yb}	y_b input amplifier	memory board	
u_{shb}			
u_{ta}	y_a input amplifier	trigger circuit	
u_{tb}	y_b input amplifier	trigger circuit	
u_d	trigger circuit	memory board	
u_{tr}	trigger circuit	memory board	
'ext. trigger'	ext. trigg. input	trigger circuit	
S2 (AC/DC trigger)	trigger circuit	switch	two connections, see figure 10
u_{oa}/u_{ya}	memory board	main board	
u_{ob}/u_{yb}			
u_{video}	video mixer	tv modulator	
u_{video}	tv modulator	video output	
VHF/UHF	tv modulator	VHF/UHF output	
Q_3	main board	'x-magn.' switch	
Q_4			
Q_3/Q_4	'x-magn.' switch	memory board	

With S1 in position 1 ('x magnitude' is 'x 1'), the Q_3 output is selected. The frequency of the pulses at this output corresponds to the frequency of the sawtooth voltage u_{ref} on the main board. The result is that the display cycle of the selected memory, the count in IC5, and the final display on the TV screen all run in step: each sample value in the memory is displayed at one point on the screen. When S1 is placed in position 2, however, the Q_4 output is selected – the frequency of which is half that of the u_{ref} sawtooth. In this case, the memory is read out at half the speed of the display sweep, so that each value stored in memory is actually displayed as a dot on two consecutive lines in the picture. This results in a final display that is 'stretched' along the time axis.

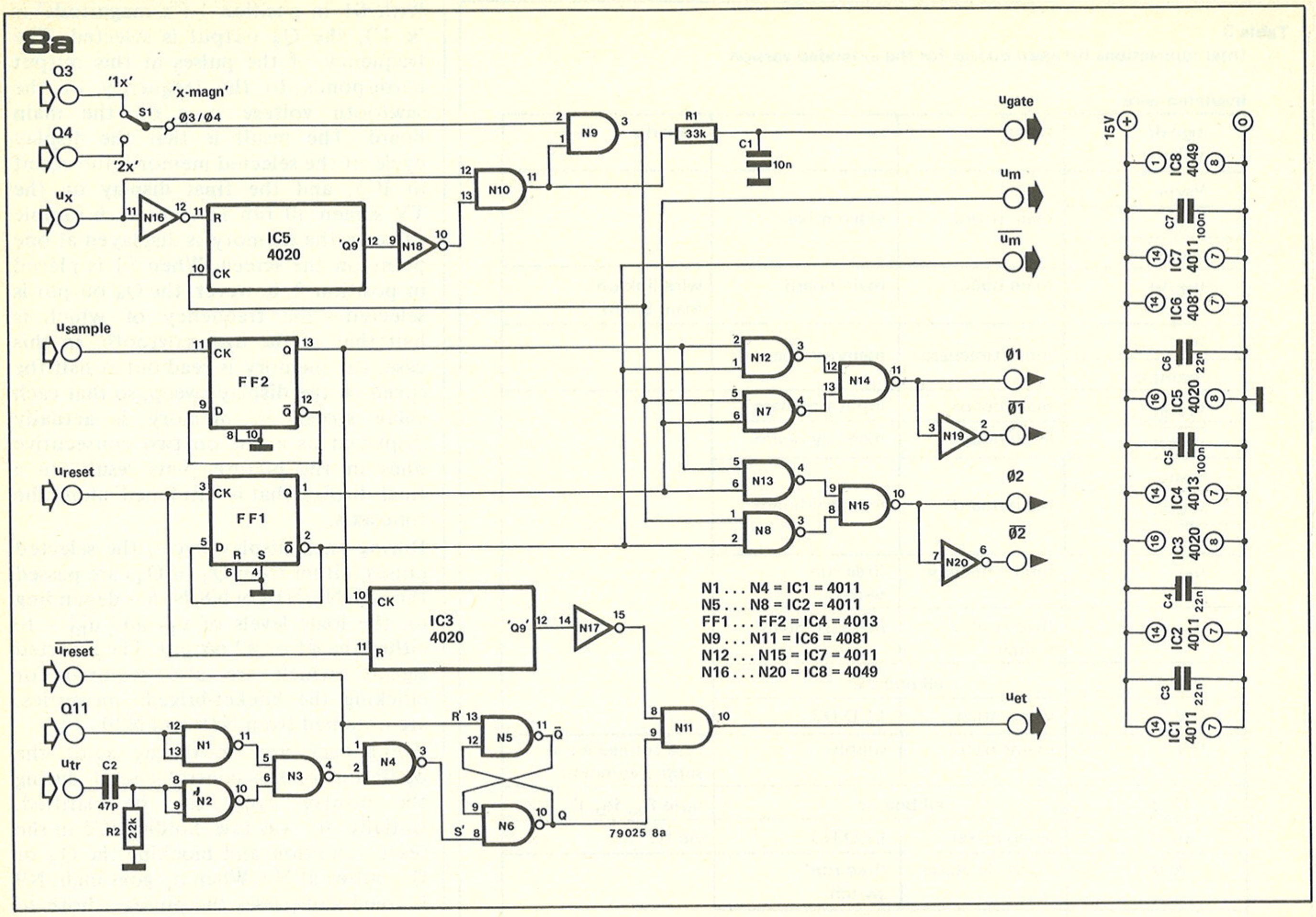
During each display cycle, the selected pulses (either from Q_3 of Q_4) are passed through N7/N14 or N8/N15 – depending on the logic levels of u_m and $\overline{u_m}$ – to either the Ø1 or Ø2 output. The inverted signals, which are also required for clocking the bucket-brigade memories, are obtained from N19 and N20.

Going back now to the u_x input, the operation of the control circuit during the display cycle can be clarified. Initially, u_x was low, holding IC5 in the reset condition and blocking the Q_3 or Q_4 pulses at N9. When u_x goes high, N9 is freed and passes the pulses – both to the Ø1 or Ø2 output, as described above, and to the clock input of IC5. After 256 pulses have been passed, IC5 reaches its maximum count; via N18 and N10 it again blocks N9, cutting off the pulse train. The count is stopped, and no further pulses are fed to the 'display' memory.

One other signal is required during the display period: u_{gate} which controls N15 in the circuit for deriving the white-level pulses for the trace display (see figure 4c in the article 'TV scope, basic version'). This signal must be 'high' when the display memory is actually being read out, and low at all other times. A suitable signal is already being used to control N9, and it is fed out via an RC-network (R1/C1) which introduces a slight delay to compensate for a similar delay caused by the low-pass filters at the output of the memory.

When one memory is in the display cycle, the other is sampling the input signal. This 'read cycle' is similar in many ways to the display cycle. A pulse at the $\overline{u_{reset}}$ input resets the RS flip-flop N5/N6 (the Q output goes 'low'); the u_{et} output is then also low. The Q_{11} signal from the main board is also low after the reset pulse, so the output of N1 is high, enabling N3. A positive-going edge at the u_{tr} input is differentiated by C2 and R2, causing the output of N3 to go 'high' briefly. This, in turn, sets the flip-flop (N5/N6); in other words, its Q output goes 'high' on the first positive edge occurring at the u_{tr} input after the reset pulse. This causes

8a



the output of N11 (the u_{et} signal) to go high, starting the input timebase oscillator (figure 6). The output from the latter, u_{sample}, is passed through a flip/flop (FF2) to obtain the input clock pulses. Depending on the mode signal, this pulse train is either fed to the Ø1 or Ø2 output to clock the memory which is in the 'read' mode. Simultaneously, the pulses are counted by IC3; when this reaches its maximum count of 256, its output goes high. This causes the u_{et} output to go low, stopping the timebase oscillator and, with that, the 'read' cycle.

In the absence of trigger pulses, no 'read' cycle would normally occur. However, approximately halfway through the total period Q_{11} goes high. This has the same effect as a trigger pulse, enabling the input timebase to initiate a read cycle. Effectively, the scope switches over to a 'free run' mode in the absence of trigger pulses.

So much for the control circuit. Not surprisingly, the second part of the 'memory board' contains the memories (figure 8b). The portions enclosed within dotted lines are identical: the upper section is for the A-channel and the lower for the y_b input. The latter section can, of course, be omitted if only a single-channel scope is required.

The heart of the circuit is IC9. This contains two independent bucket-brigade delay lines, each with 512 'buckets'. Clock signals Ø1 and $\overline{Ø1}$ are fed to one of these delay lines; Ø2 and $\overline{Ø2}$ are used to clock the other. In Principle, both delay lines could receive the same input signal; in practice, however, u_{sh} (for 'shifted) is not quite identical to u_y. As is apparent from the circuit of the input amplifier (figure 2 in the article dealing with the basic version – see page 10-31 in the October issue), both the signal amplitude and the superimposed DC level of the u_{sh} signal can be varied slightly with respect to u_y. This is done to compensate for any minor differences between the two delay lines, as will be described for the calibration procedure.

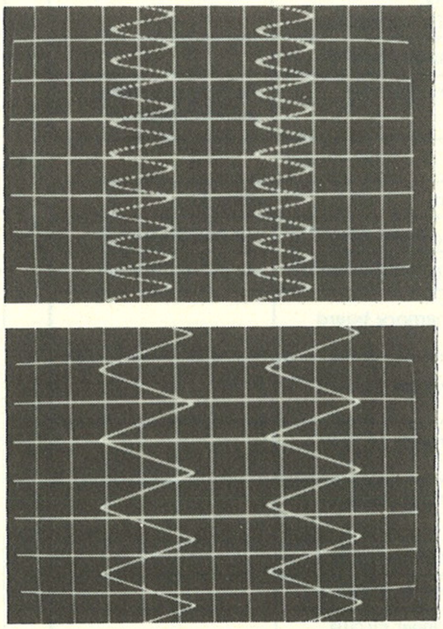
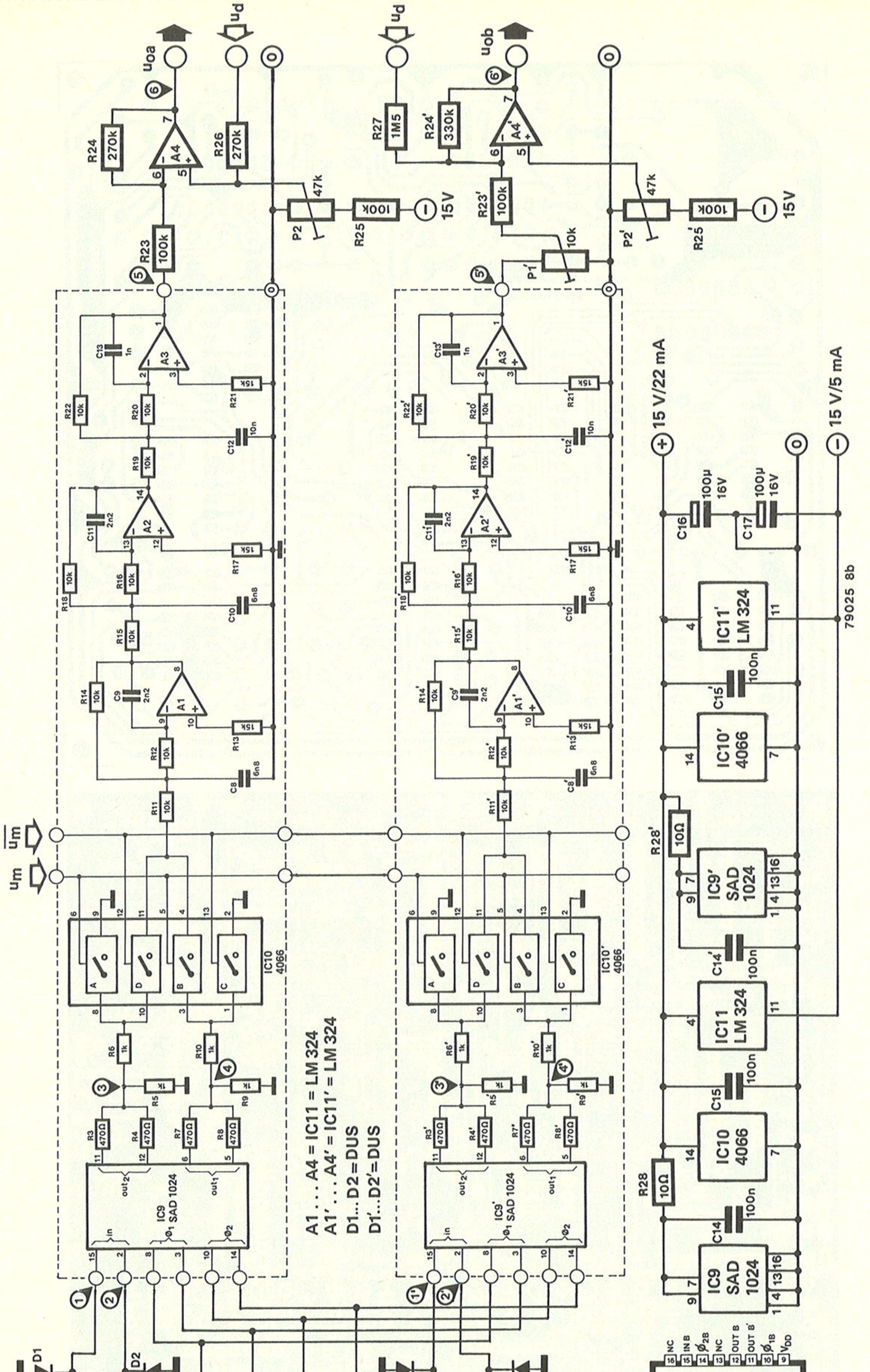


Figure 8. Two closely related circuits are mounted on the 'memory board': the control circuit (figure 8a) and the memory circuit proper (figure 8b). For a two-channel version of the scope, two memory circuits are required; in figure 8b both of these circuits are shown in full.

The two delay lines in IC9 each have two outputs. Mixing these two outputs in a resistor network helps to suppress the clock components, providing a total analogue output (at point 3 or 4, respectively) that is relatively 'clean'. Under control from the 'mode' signals (u_m and $\overline{u_m}$), the analogue switches contained in IC10 select one of the two memory outputs for display purposes. The 'unwanted' output is connected unceremoniously to ground.

The selected output is fed through a sixth-order low-pass filter, A1 . . . A3, with a turnover frequency of 2.5 kHz. This frequency corresponds to the highest frequency the basic version of the TV scope can be expected to display. At the end of the chain (at point 5) a clean, time-expanded replica of the original analogue input signal is now available for display purposes. Or rather, not quite. The A-channel output is amplified slightly (approximately times three) and a DC component is added to

8b


u_ya
u_sha
u_yb
u_shb
Ø1
Ø̄1
Ø2
Ø̄2
R29 1k
R30 1k
R29' 1k
R30' 1k
D1
D2
D1'
D2'
IC9 SAD 1024
IC9' SAD 1024
in
out2
out1
ϕ1
ϕ2
R3 470Ω
R4 470Ω
R7 470Ω
R8 470Ω
R5 1k
R9 1k
R6 1k
R10 1k
IC10 4066
IC10' 4066
A
D
B
C
u_m
ū_m
R11 10k
R12 10k
R13 15k
R14 10k
R15 10k
R16 10k
R17 15k
R18 10k
R19 10k
R20 10k
R21 15k
R22 10k
C8 6n8
C9 2n2
C10 6n8
C11 2n2
C12 10n
C13 1n
A1
A2
A3
A4
A1'
A2'
A3'
A4'
R23 100k
R24 270k
R26 270k
R25 100k
P2 47k
15V
R23' 100k
R24' 330k
R27 1M5
R25' 100k
P1' 10k
P2' 47k
u_oa
u_ob
u_d
0
A1 . . . A4 = IC11 = LM 324
A1' . . . A4' = IC11' = LM 324
D1 . . . D2 = DUS
D1' . . . D2' = DUS
+15 V/22 mA
−15 V/5 mA
C16 100µ 16V
C17 100µ 16V
IC11 LM 324
IC11' LM 324
IC10 4066
IC10' 4066
IC9 SAD 1024
IC9' SAD 1024
C14 100n
C15 100n
C14' 100n
C15' 100n
R28 10Ω
R28' 10Ω
SAD 1024
GND
IN A
ϕ2A
NC
OUT A
OUT A'
VDD
ϕ1A
NC
IN B
ϕ2B
NC
OUT B
OUT B'
ϕ1B
VDD
79025 8b

9

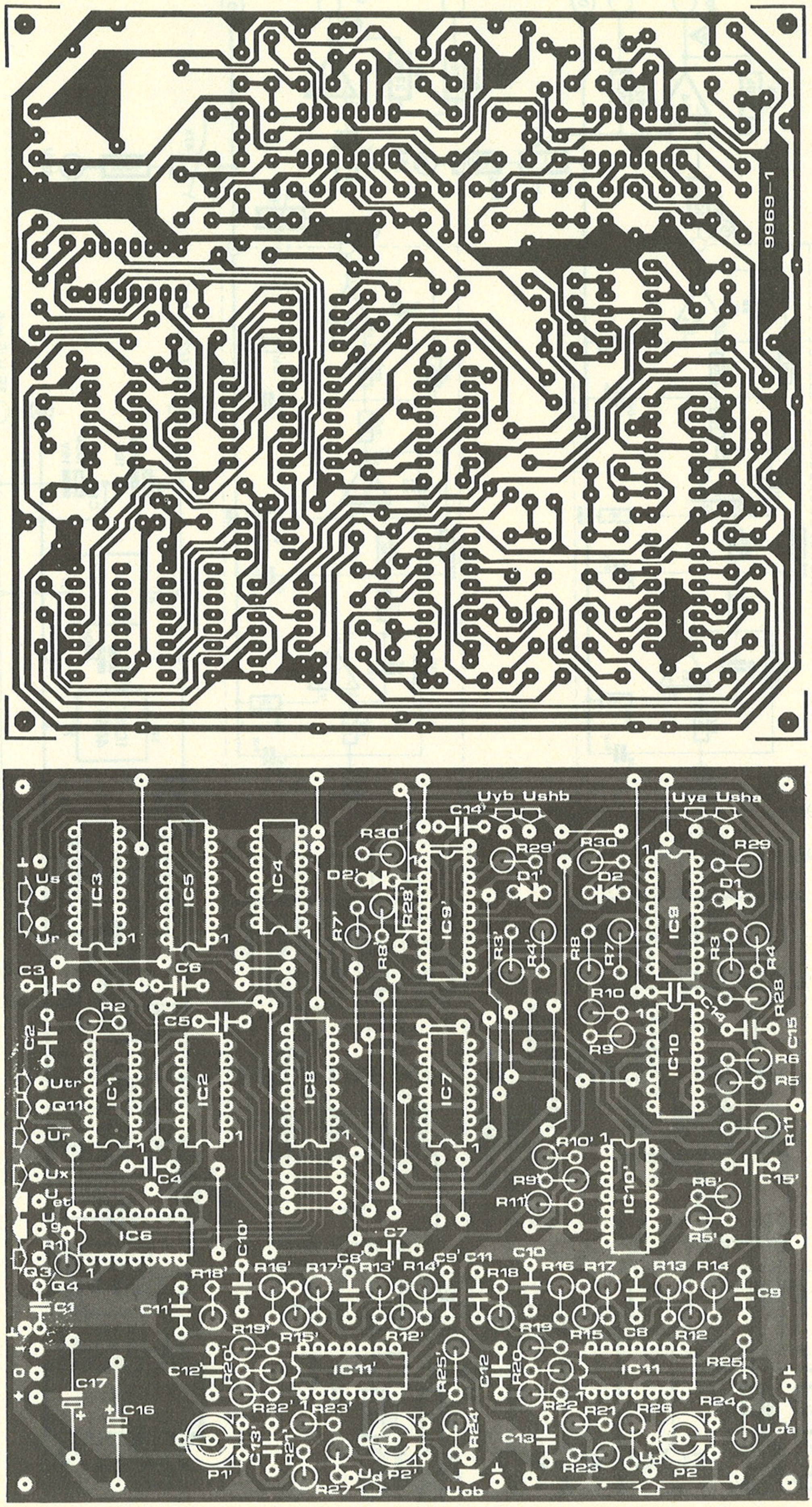

9969-1
Uyb Ushb
Uya Usha
C14'
R30'
R29'
R30
R29
D2'
D1'
D2
D1
R28'
IC9'
IC9
R7'
R8'
R3'
R4'
R8
R7
R3
R4
R28
R10
R9
C14
C15
IC10
R6
R5
R11
R10'
R9'
R11'
IC10'
R6'
R5'
C15'
IC3
IC5
IC4
Us
Ur
C3
C6
R2
C5
C2
IC1
IC2
IC8
IC7
Utr
Q11
Ur
C4
Ux
Uet
Ug
IC6
R1
Q3
Q4
C1
C7
C8'
C9'
C11
C10
C10'
R18'
R16'
R17'
R13'
R14'
R18
R16
R17
R13
R14
C9
C11'
R19'
R15'
R12'
R19
R15
C8
R12
C12'
R20'
IC11'
R25'
C12
R20
IC11
R25
C17
C16
R22'
R23'
R21'
C13'
R24'
C13
R22
R21
R26
R24
P1'
P2'
Ud
R27
Uob
R23
Ud
P2
Uoa

Table 4

Supply currents (mA)

circuit	board no.	+15 V	−15 V
input amplifier*	9968-1	5 . . . 9	5 . . . 7
main board	9968-2	45	20
video mixer	9968-3	9	—
memory board	9969-1	22	5
trigger circuit	9969-2	25	20 . . . 25
input timebase	9969-3	20	—
VHF/UHF TV modulator	9967	15	—
sync circuit**	9968-4	4	—

* two required for two-channel version of TV scope
** only required for basic version of TV scope

Figure 9. The 'memory board' (EPS 9969-1). Insulated wire should be used for the wire links wherever there is any danger of inadvertent short circuits. Furthermore, the resistors are mounted 'on end' in order to keep the size of the board within reasonable limits.

Parts list memory board

Resistors:
R1 = 33 k
R2 = 22 k
R3,R3',R4,R4',R7,R7',
R8,R8' = 470 Ω
R5,R5',R6,R6',R9,R9',
R10,R10',R29,R29',
R30,R30' = 1 k
R11,R11',R12,R12',
R14 . . . R16,R14' . . . R16',
R18 . . . R20,R18' . . . R20',
R22,R22' = 10 k
R13,R13',R17,R17',
R21,R21' = 15 k
R23,R23',R25,R25' = 100 k
R24,R26 = 270 k
R24' = 330 k
R27 = 1M5
R28,R28' = 10 Ω
P1' = 10 k preset
P2,P2' = 47 k (50 k) preset

Capacitors:
C1,C12,C12' = 10 n
C2 = 47 p
C3,C4,C6 = 22 n
C5,C7,C14,C14',
C15,C15' = 100 n
C8,C8',C10,C10' = 6n8
C9,C9',C11,C11' = 2n2
C13,C13' = 1 n
C16,C17 = 100 μ/16 V

Semiconductors:
D1,D1',D2,D2' = DUS
IC1,IC2,IC7 = CD 4011
IC3,IC5 = CD 4020
IC4 = CD 4013
IC6 = CD 4081
IC8 = CD 4049
IC9,IC9' = SAD 1024 (Reticon)
IC10,IC10' = CD 4066
IC11,IC11' = LM 324

Sundries:
S1 = single-pole,
single-throw switch

Table 5

Calibration data for the input timebase (see text)

time/div.	preset	calibration signal	IC5 (main board) pin no.	calibration signal		number of divisions	f_{sample}
				frequency	period time		
2 ms	P7	Q8	13	480 Hz	2.08 ms	1.0	31.98 kHz
1 ms	P6	Q7	4	960 Hz	1.04 ms	1.0	63.96 kHz
500 μs	P5	Q6	2	1.92 kHz	520 μs	1.0	127.9 kHz
250 μs	P4	Q5	3	3.84 kHz	260 μs	1.0	255.8 kHz
100 μs	P3	Q5	3	3.84 kHz	260 μs	2.6	639.6 kHz
40 μs	P2	Q3	6	15.38 kHz	65 μs	1.6	1599 kHz

produce the final output, u_{oa}, which is fed to the input of the main board. The output of the B-channel undergoes similar treatment, with one minor difference. The fixed gain is slightly greater (R24' is slightly larger than R24), but this output level can be reduced by means of P1'. In effect, therefore, the total gain at the output of the B-channel can be adjusted to compensate for any minor differences in the attenuation caused by all the preceding stages. The adjustable DC shift set by P2 brings the output level into line with the sawtooth reference voltage on the main board.

One last point remains to be discussed: the 'trace distance' control, P2 in figure 4, which was mentioned briefly in connection with the board for the trigger circuit. The DC output from this potentiometer, u_d, is connected via R26 and R27 to the non-inverting input of the A-channel output amplifier and the inverting input of its partner in the B-channel. The term 'trace distance' aptly describes the function of this control: it shifts the two traces in opposite directions on the screen. At one end of the control range, the two traces will overlap (useful for comparison of minor differences between the two), whereas at the other end of the range the two traces are each approximately centered on their own half of the screen.

All the circuits shown in figures 8a and 8b are mounted on a single p.c. board, the memory board, as given in figure 9. In order to pack such a large number of components on a relatively small, single-sided board, the ease of construction has had to be sacrificed to some extent. Insulated wire will be required for several of the wire links, to avoid the possibility of highly undesirable short circuits. Furthermore, in marked contrast to most Elektor boards, the resistors are mounted 'on end' and care should be taken to avoid shorts between the long connections to adjacent resistors. Switch S1 ('x magn') is mounted off board, as shown in figure 10.

The components for the B-channel normally have the same values as their opposite numbers in the A-channel (e.g. R3 = R3' = 470 Ω). There are two exceptions to this rule: R24 (A-channel) = 270 k, whereas R24' (B-channel) = 330 k; furthermore, preset P1' (B-channel) is not included in the A-channel circuit. If a single-channel version of the TV scope is required, all components for the B-channel may be omitted.

For test purposes, some voltages at the various test points are listed in Table 1. Further details are given in the description of the calibration procedure.

All the bits . . .

The three boards described in this article, together with those already described for the basic version, are all that is needed for the extended version of the TV scope. As an aid in procuring the necessary components, all the relevant parts lists have been compressed into one complete 'bulk parts list': 146 resistors, 10 potentiometers, 20 preset potentiometers, 82 capacitors, 34 ICs, 24 other semiconductors, 11 switches and a few 'sundries'.

For each component value or type, the quantity required for the complete extended version of the scope (basic version plus extension circuits) is listed

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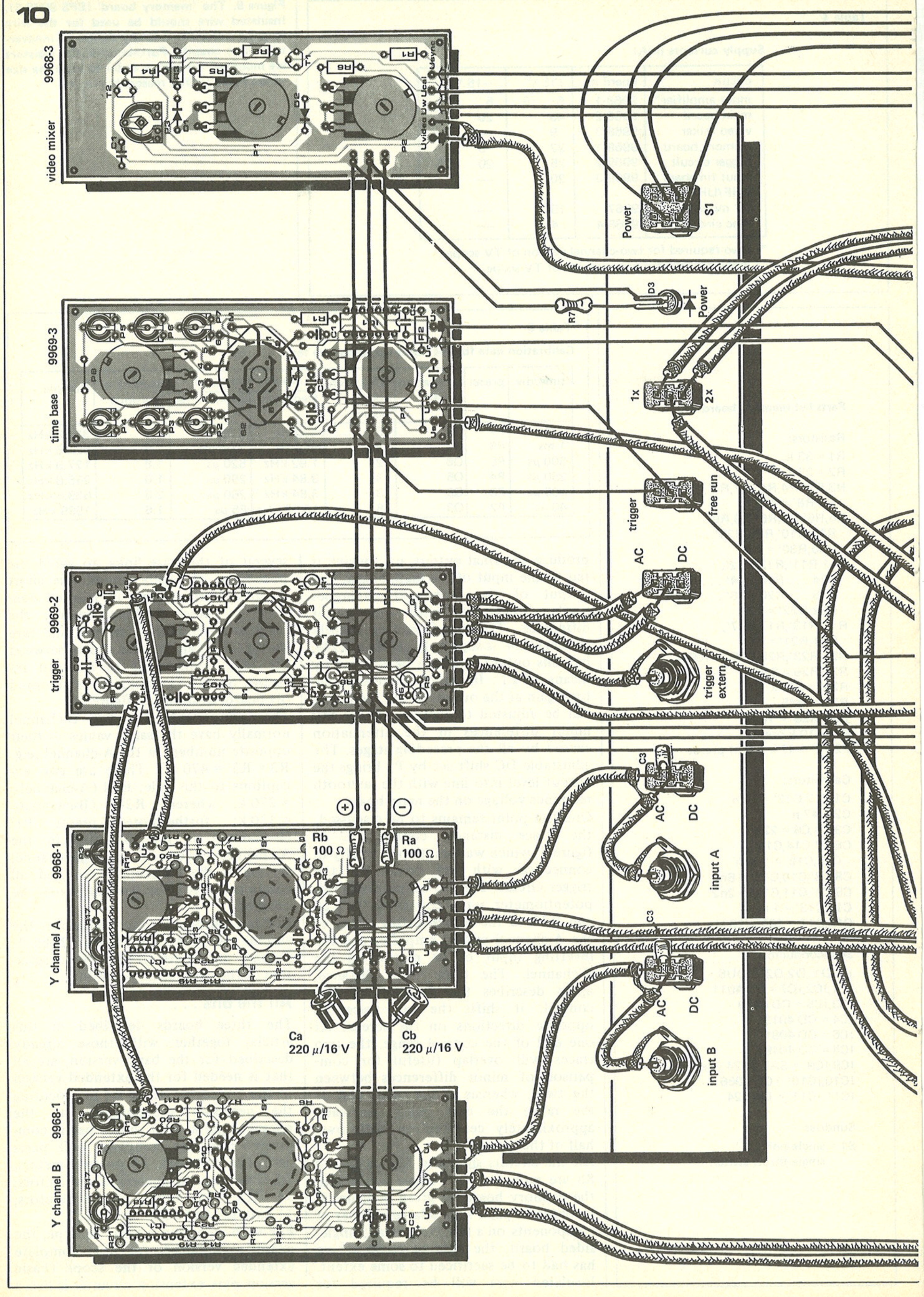

video mixer
9968-3
time base
9969-3
trigger
9969-2
Y channel A
9968-1
Y channel B
9968-1
Power
S1
D3
R7
Power
1x
2x
trigger
free run
AC
DC
trigger extern
C3
AC
DC
input A
C3
AC
DC
input B
Rb
100 Ω
Ra
100 Ω
+
0
−
Ca
220 µ/16 V
Cb
220 µ/16 V

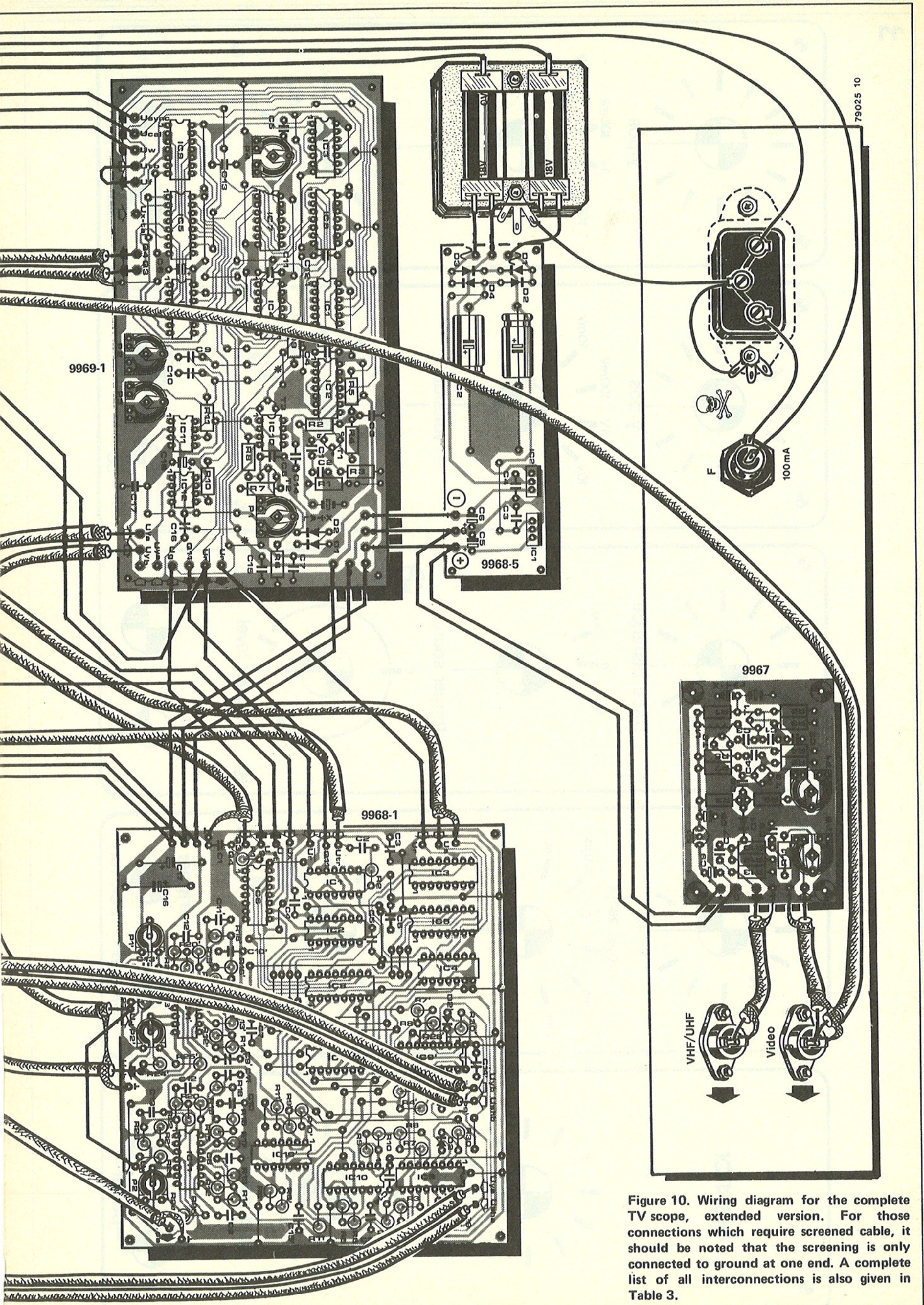
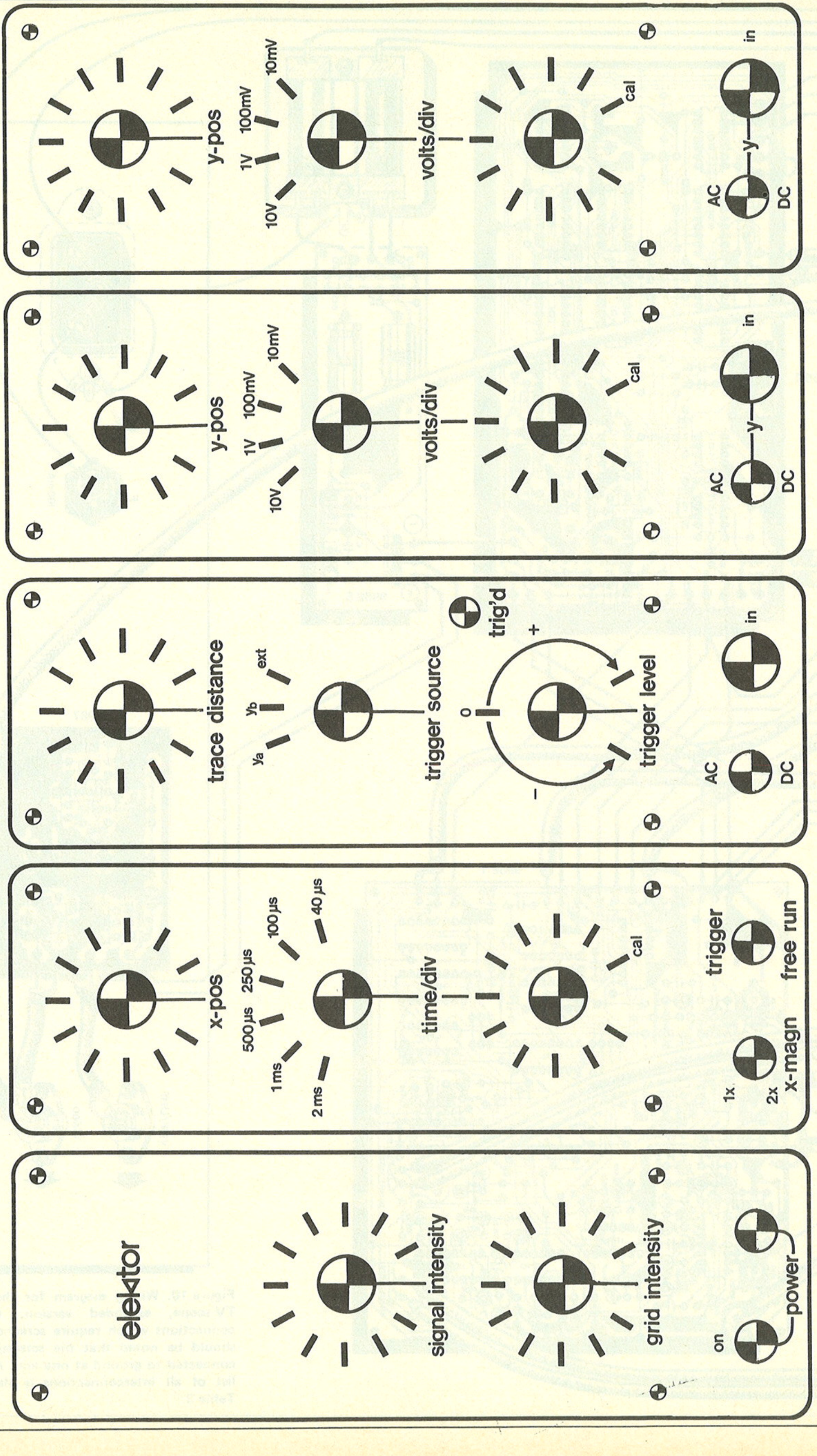


Figure 10. Wiring diagram for the complete TV scope, extended version. For those connections which require screened cable, it should be noted that the screening is only connected to ground at one end. A complete list of all interconnections is also given in Table 3.

11


y-pos
10V
1V
100mV
10mV
volts/div
cal
AC
DC
y
in
y-pos
10V
1V
100mV
10mV
volts/div
cal
AC
DC
y
in
trace distance
ya
yb
ext
trigger source
0
+
–
trig'd
trigger level
AC
DC
in
x-pos
2 ms
1 ms
500 µs
250 µs
100 µs
40 µs
time/div
cal
1x
2x
x-magn
trigger
free run
elektor
signal intensity
grid intensity
on
power

in one column; a second column gives the quantities required for extending the basic scope. Both columns are valid for the complete two-channel TV scope. To avoid misunderstandings: in the first column ('complete'), the components required for the UHF/VHF TV modulator are also listed (see the recent October issue, page 10-27). This was not the case in the bulk parts list for the basic version of the TV scope given in the October issue.

Back to the basic version

During extensive testing of the extended version of the TV scope, it was discovered that some samples of the analogue delay-line ICs exhibited noticeable anaomalies in their signal-storage characteristics. This effect is less apparent if larger signal levels are used.

For this reason, one or two minor modifications of the basic version are required if it is to be used in conjunction with the extension circuits. Note that there is no advantage in incorporating these modifications in the basic scope if it is not to be extended — although they won't do any harm, either.

As shown in Table 2, three resistor values are changed: two in each y-input amplifier (four resistors in total for a two-channel scope) and one resistor on the main board. These components are included in the bulk parts list.

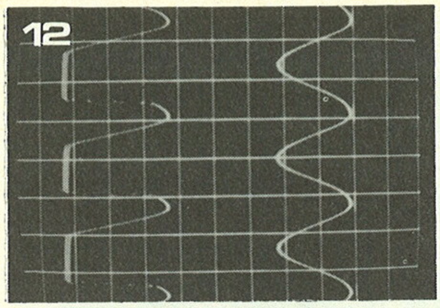
The effect of the modifications in the input amplifier is to significantly increase its output level, making it more suitable for processing in the analogue delay lines. A minor disadvantage is a slight reduction in bandwidth: − 6 dB at 100 kHz, instead of the original − 3 dB. Since the input signal to the main board is now at a higher level, the amplitude of the reference sawtooth must be increased in step. This is accomplished by modifying the value of one resistor on the main board.

Construction

The connections between the various boards are shown in figure 10. The position of the boards corresponds to the lay-out of the front panel shown in figure 11. The front-panel controls are listed in Table 6, with a brief description of their function.

Construction of the complete unit is basically similar to that of the basic version, as described in the October issue. Suitable cases are available from West Hyde (type DES 306) and GSA (type V7004). As with the basic version, it is advisable to screen the more sensitive circuits (input amplifiers, trigger circuit, input timebase and video mixer) with strips of copper laminate board which can be soldered to the earth plane.

The interconnections between the various boards are also listed in Table 3. For those connections which require screened cable, it should be noted that the screening is only connected to supply common at one end, to avoid ground loops.



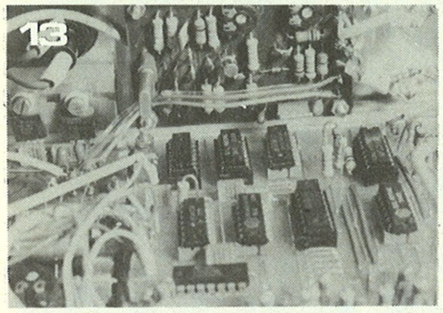


Figure 11. Front panel layout for the extended version of the TV scope. Table 6 lists the front-panel controls, with a brief description of their function.

Figure 12. A word of warning! The bucket-brigade delay-lines have a limited dynamic range, and excessively large input signals will be clipped, as shown here.

Figure 13. Detail of the interior of the prototype. To the left of the picture, the main supply regulators are mounted on the back panel.

As shown in figure 10, the supplies to the input amplifiers are decoupled by means of two resistors, R_a and R_b (100 Ω), and two electrolytic capacitors (C_a and C_b, 220 μ/16 V). These components are mounted 'off board', as shown.

When comparing the basic version with the extended version, it may be noticed that the 'reset' output is omitted from the latter. This provision is not required in the extended version, since it has adequate triggering facilities. However, if the 'reset' output is already mounted there is no point in removing it.

The two IC voltage regulators in the main supply should be adequately cooled, for instance by mounting them (with mica insulation!) on the back of the case. The main reason for this is to keep the heat out of the case: experiments have shown that the performance of the bucket-brigade delay lines, in particular, deteriorates rapidly as the ambient temperature rises. There is no need to cool the regulator on the UHF/VHF modulator board.

A further aid when constructing and testing the TV scope is the list of supply currents for the various circuits, given in Table 4. The current consumption of the complete TV scope (extended version, two-channel, including the VHF/UHF modulator) is approximately 150 mA from the positive supply (+15 V) and 55 mA from the − 15 V supply.

Before applying power for the first time, it is advisable to first give the wiring a final 'once-over', checking for inadvertent short circuits. Some photos of the completed unit are given in figures 13 . . . 15. To play things safe, the supply can be connected to the various boards one at a time: first disconnect the output from the main supply, apply power and check the +15 V and −15 V outputs. The other boards are then connected to the supply one at a time, checking the supply current against Table 4. Differences of up to 10% are no cause for alarm.

Once all the boards have been connected up and checked in this way, it is time for the final step: the calibration procedure.

Initial calibration

In spite of the 20 presets involved, calibration of the TV scope is not too difficult. The only measuring equipment required is a standard universal meter, with a sensitivity of at least 10 kΩ/V.

The first step is to calibrate the components associated with the basic version of the TV scope. The relevant adjustment procedures were discussed in the article in the October issue. If one has already built and calibrated the basic version and is now adding the extension circuits, the only adjustment affected by the component modifications according to Table 2 is the setting of P1 on the main board. How-

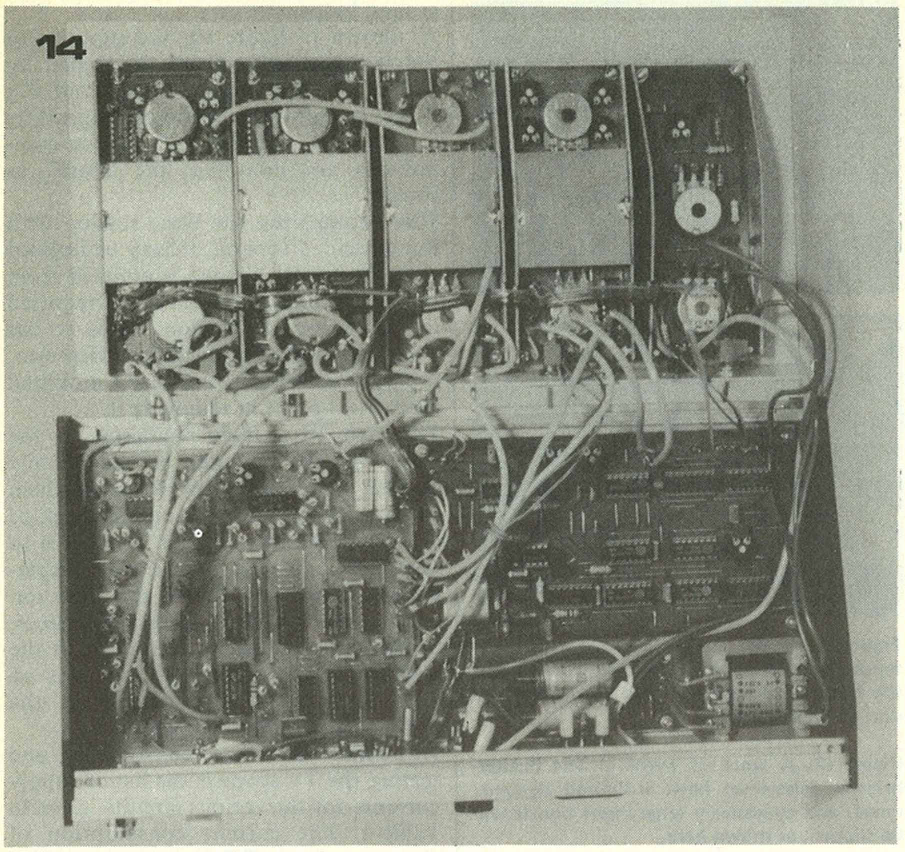
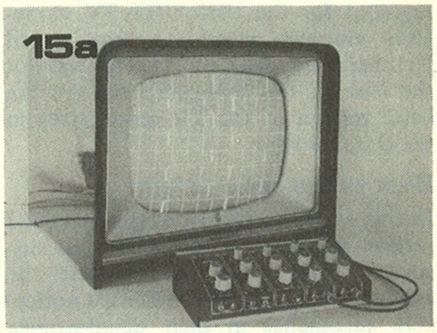
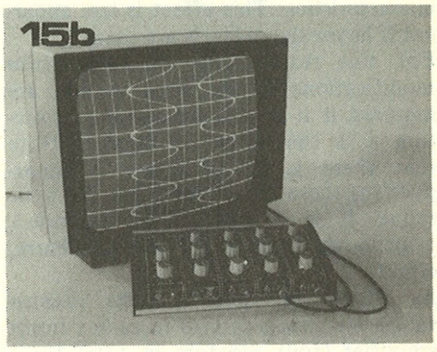

14

Figure 14. Complete unit, with all wiring and screening panels in place.

Figure 15. A 10 kHz square-wave on an ancient TV set and a 20 kHz sine-wave on a more recent model . . .


15a


15b

ever, final adjustment of this preset is part of the calibration procedure about to be described. The setting of all other presets in the basic version remains unaltered, with the exception of P3 and P4 on the input amplifier board(s). These two potentiometers have no influence on the operation of the basic version.

Having completed the adjustment procedure outlined for the basic version, the next step is to adjust P4 in the input amplifier. For this initial (approximate) adjustment, no input signal is required. The controls of the y-amplifier are set as follows: 'volts/div' selector switch a 10 V and corresponding potentiometer fully clockwise ('cal'); 'AC/DC' switch in position 'AC'. Initially, set P3 and P4 in their mid-positions. Measure the voltage at test point 1 (or 1') on the memory board, and adjust the 'y-pos' control to obtain 5.5 V at this point. Now measure the voltage at point 2 (2') and adjust P4 until 5.5 V is obtained at this point also. This adjustment is sufficiently accurate for the time being.

Operation of the bucket-brigade memories can now be checked. To this end, the 'trace distance' control is turned fully anti-clockwise; the 'time/div' switch is set to 500 µs, and the corresponding potentiometer fully clockwise ('cal'); the 'trigger/free run' switch is set to 'free run'; all presets on the input timebase board are set to their mid-position. The voltages at test points 3 and 4 (3' and 4') should now be approximately 3 V; furthermore, it should be possible to vary these voltages over a total range of about 1 V (e.g. from 2.5 V to 3.5 V) by means of the 'y-pos' control. If this is the case, the memories are in working order.

The next point to check is the voltage at point 5 (5'). This should be approximately equal in value to the voltage at points 3 and 4 (3' and 4'), but negative with respect to supply common. In other words, if the voltages at points 3 and 4 are indeed 3 V, the voltage at point 5 should be approximately −3 V.

This being the case, the next step is to measure the voltage at point 6 (6') and set it to approximately +4 V by means of P2 (P2'). For the time being, P1' is set to the mid-position.

The output of the TV scope should now be connected to a TV receiver. P1 on the main board (basic version) is adjusted until vertical lines appear that are not part of the calibration graticule. In principle, there should be four of these lines, but it is possible that one or more of them are actually off the screen. If this is the case, the missing lines can be brought into the picture by adjusting P2 (P2') on the memory board.

One pair of lines is generated by the A-channel. This pair can be found by operating the corresponding 'y-pos' control: the lines can be shifted over a total range of approximately 4 scale divisions, or just less than half the width of the screen (the range is limited by the maximum output swing of the bucket-brigade memories). The y-position controls for both channels are now set so that the corresponding vertical lines are mid-way between their two extreme positions. Finally, P4 on the input amplifier board(s) is adjusted until the corresponding pair of lines become one: the zero-volt line for that particular channel.

This completes the initial setting-up procedure; the next step is the final calibration.

Final calibration

If a dual-channel version of the scope is being calibrated, it is a good idea at this point to adjust P2' on the memory board so that the zero-volts line for the B-channel is moved to the edge of the screen. For the present, the A-channel display is the only one which is of interest.

The first step is to calibrate the input timebase. For this, a stable and accurate AC test signal is required. Fortunately, no expensive test equipment is required: a suitable signal can be derived from the TV scope itself. The input of the y_a input amplifier is connected to pin 2 ('Q_6') of IC5 on the main board (basic version). Since this is a digital IC and the relevant oscillator is crystal-controlled, the signal at this point is known: it is a squarewave with a peak-to-peak amplitude of 15 V and a frequency of 1.92 kHz, corresponding to a period time of 520 µs.

With the 'trigger source' selector switch set to 'y_a', it should now be possible to adjust the 'trigger level' control so that the 'trig'd' LED lights. This adjustment is fairly critical. The 'trigger/free run' switch is now set in position 'trigger', whereupon a stable picture should appear on the screen. The square-wave trace can be moved horizontally and vertically across the screen by means of the 'y-pos' and 'x-pos' controls, respectively. Note that the y-position control should be adjusted so that the trace is centered in its range, as otherwise the signal will be clipped by the delay-lines.

At this stage, the display will almost

Table 6

Front-panel controls

function	part no.	figure no.*	remarks
power	S1	B14	mains switch
signal intensity	P1	B7	intensity of trace
grid intensity	P2	B7	intensity of calibration graticule
x-pos	P8	E6	trace position on x-axis
time/div**	S2,P1	E6	x-axis scale
x-magn	S1	E8a	'1x': scale corresponds to that selected by 'time/div' switch; '2x': x-axis scale multiplied by 2
trigger/free run	S1	E6	trigger circuit enable; select 'free run' in absence of trigger signal
trigger source	S1	E4	selector switch for trigger signal
trig'd	D2 (LED)	E4	indicator LED, lights if trigger signal is present
trigger level	P1	E4	reference level for signal selected as 'trigger source'
trace distance	P2	E4	sets distance between the two traces for A- and B-channel
y-pos	P2	B2	trace position on y-axis
volts/div**	S1,P1	B2	y-axis scale
AC/DC	S2	B2/E4	AC or DC coupling of input signal at respective input

* Figure numbers preceded by the letter 'B' refer to figures in the article 'TV scope, basic version' in the October issue; figure numbers preceded by letter 'E' refer to figures in this article.

** The values given for the various switch positions are only valid if the corresponding potentiometer is in position 'cal'.

certainly consist of two square-waves, one corresponding to each of the delay-lines in the A-channel. The differences between the two signal paths can now be compensated, by means of presets P3 and P4 in the A- input amplifier. The slight difference in gain between the two delay-lines can be compensated for by adjusting P3 until the amplitude of the two square-wave signals is identical; the varying DC shifts are brought into line by setting P4 so that both traces are symmetrical around the same centre-line – in other words, the y-position of both traces should be identical. Since these adjustments interact, this adjustment procedure must be repeated until no further improvement is obtained.

Having reduced the display to a single square-wave signal, the next step is to calibrate the input timebase. With the 'time/div' switch in position 500 μs and the corresponding potentiometer in position 'cal', one complete period of the square-wave should correspond to a fraction over one division – 520 μs is 1.04 divisions. The preset potentiometer P5 on the input timebase board is adjusted until the correct period length is obtained.

The 'volts/div' selector switch should still be set at '10 V'. This means that the 15 V peak-to-peak square-wave should correspond to an amplitude of 1.5 divisions. This result can be obtained by (re-) adjusting P1 on the main board of the basic version. It will be noticed that this adjustment also influences the y-position, but this shift can be compensated for by readjusting P2 on the memory board.

The same adjustment procedure can now be carried out for the second (B-) channel, after first bringing the corresponding 'zero-volts line' back into the centre of the picture by re-adjusting P2' on the memory board. There is, however, one difference in the calibration procedure: the amplitude setting (for 1.5 horizontal divisions) is carried out by means of P1' on the memory board, instead of using P1 on the main board.

For the B-channel, the procedure can therefore be summed up briefly as follows: P3 and P4 on the B-channel input amplifier are adjusted until the two square-wave signals overlap; the timebase, obviously, needs no re-adjustment, since it is common to both channels; P1' on the memory board is so that the amplitude of the square-wave signal corresponds to 1.5 horizontal divisions; finally, P2' on the memory board is adjusted to compensate for DC shift (y-position).

Final adjustment of P2 and P2' is now in order. The 'trace distance' control should still be set fully anti-clockwise ('overlap') and the 'y-position' controls are both set so that the corresponding traces (with no input signal applied) are midway between their two extreme positions. P2 and P2' can now be adjusted so that the corresponding traces overlap in the exact centre of the screen.

The remaining presets in the input timebase now require attention – P5 has already been adjusted. The other presets are calibrated in the same way – the 'trigger level' control being manipulated to obtain a stationary display. Suitable calibration signals are derived from the TV scope itself, and the relevant preset on the input timebase board is adjusted until the correct period length is obtained. All timing signals are derived from IC5 on the main board. All relevant details are given in Table 5: the position of the 'time/div' selector switch; the corresponding preset potentiometer; the necessary calibration signal, and the pin number (of IC5) from which this signal can be obtained; the frequency and period time of this signal; the number of divisions that corresponds with one complete period of this signal when the preset is correctly adjusted. The last column in this table gives the correct frequency (f_{sample}) of the u_{sample} signal, for the benefit of those who have access to a frequency counter: setting the 'trigger/free run' switch in position 'free run' causes the timebase oscillator to run continuously, so that it can be measured and calibrated accurately without the need for recourse to calibration signals. For completeness' sake, the calibration data for P5 are also listed in Table 5, even though this adjustment has already been completed at an earlier stage.

A possible complication in the '2 ms/div' position is that it may prove impossible to obtain a stationary display. The reason for this problem is that in this case the 'read' cycle may take so long that it overlaps the 'display' cycle – the memories are read out before they have been completely read in! In this case, triggering is not possible and the 'trigger/free run' switch may as well be set in the 'free run' position.

The adjustment of the input timebase was the last step in the calibration procedure. It may, however, prove useful to give all adjustments a final once-over. In particular, presets P3 and P4 in the input amplifiers may require

Bulk parts list for extended version of TV scope
(two input amplifiers, main board, video mixer, input timebase, trigger circuit, memory board, VHF/UHF TV modulator and supply — note that the sync circuit is not required for the extend version)
'complete' (second column) gives the total number of each component type required for the TV scope in extended version; 'extension only' (third column) lists the components required to extend the basic version

Resistors:

value	complete	extension only
10 Ω	3	2
47 Ω	4	1
68 Ω	1	
100 Ω	4	2
150 Ω	1	
220 Ω	2	1
270 Ω	1	
330 Ω	1	1
470 Ω	10	8
820 Ω	2	
1 k	21	12
1k5	1	
2k2	1	
3k3	1	
4k7	1	1
5k6	4	2
6k8	1	
8k2	4	
10 k	26	20
12 k	2	
15 k	12	6
18 k	2	
22 k	3	2
33 k	3	1
47 k	2	
82 k	6	
100 k	15	7
220 k	2	
270 k	2	2
330 k	1	1
390 k	1	1
680 k	1	1
820 k	2	
1M5	1	1
2M2	2	2

Linear potentiometers:

value	complete	extension only
2k2 (2k5)	1	1
10 k	2	
22 k (25 k)	1	1
47 k (50 k)	1	1
100 k	3	1
220 k (250 k)	1	
470 k (500 k)	1	

Preset potentiometers:

value	complete	extension only
1 k	2	
2k2 (2k5)	2	
4k7 (5 k)	2	
10 k	4	1
47 k (50 k)	10	8

Capacitors:

value	complete	extension only
3p3	1	1
8p2	3	
15 p	2	
18 p	1	1
22 p	1	
33 p	2	
47 p	1	1
82 p	1	
100 p	5	2
120 p	1	
220 p	1	
560 p	1	1
1 n	2	2
2n2	4	4
6n8	4	4
10 n	5	3
22 n	4	4
100 n	24	8
1 μ	1	1
1 μ/25 V tantalum	10	2
2μ2/25 V tantalum	1	
4μ7/35 V tantalum	1	
100 μ/16 V	2	2
220 μ/16 V	2	2
470 μ/35 V	2	

Semiconductors:

type	complete	extension only
CD 4011	6	2 (3)*
CD 4012	1	
CD 4013	2	1
CD 4017	1	
CD 4020	2	2
CD 4040	1	
CD 4049	1	1
CD 4066	2	2
CD 4068	1	
CD 4071	1	
CD 4081	1	1
CD 4093	1	1
709	3	1
741	2	1
LM 324	2	2
TL 084	2	
SAD 1024	2	2
78L05	1	
7815	1	
7915	1	
TUN	3	
TUP	1	
BF 494	3	
BFY 90	1	
DUS	9	5
1N4001	4	
1N4148	1	
LED	2	1

switches:

type	complete	extension only
single-pole, single-throw	4	2
double-pole, single-throw	1	
double-pole mains switch	1	
single-pole, 3-way	2	2
single-pole, 4-way	2	
2-pole, 6-way	1	1

sundries (complete):

4.433 MHz (colour TV) crystal	1	1
27 MHz (approx.) crystal	1	1
1 μH mini-choke	1	1
100 mA fuse	1	1
2x18 V/250 mA mains transformer	1	1

* 2 off if the CD 4011 originally mounted on the sync board can be re-used on the memory board, otherwise 3 off.

minor re-adjustment after the 'bucket-brigade' ICs have warmed up. These chips have proved to be rather sensitive to changes in ambient temperature, with shifts in output level that vary from one sample to the next. This may result in trace 'flicker' after the unit has warmed up (actually, two separate traces are displayed very close together, giving a flickering effect) but this can be eliminated by slight re-adjustment of P3 and P4. A good test signal for this final adjustment is a sine-wave with an amplitude of about three divisions on the screen.

'There's a hole in the bucket'

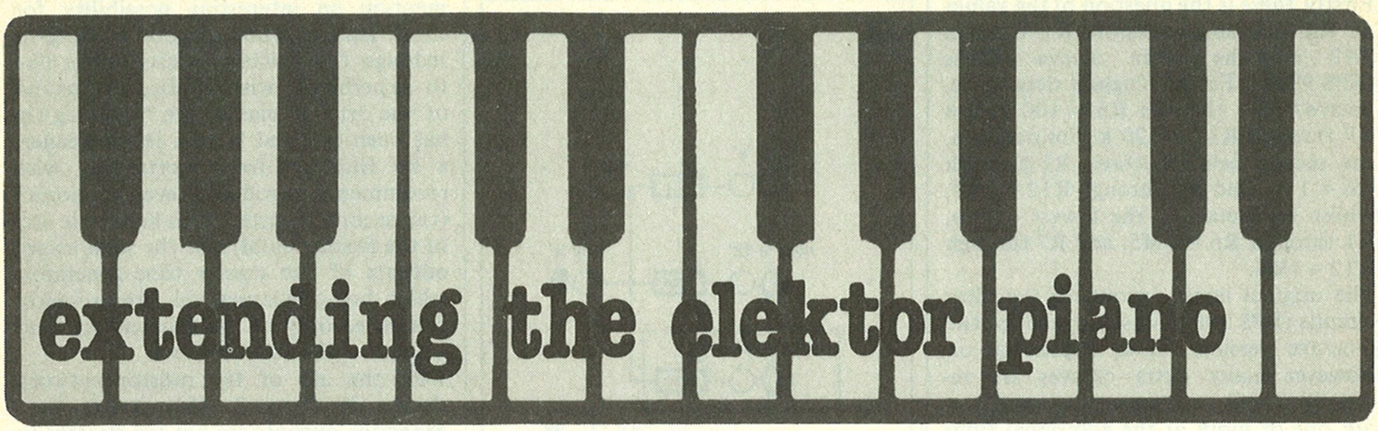
The Reticon SAD1024 bucket-brigade delay-line is a useful IC, but it is intended primarily for audio reverberation systems. Tests have shown that a small percentage of these ICs contain one or more 'leaky buckets'. Since, in the TV scope, the input signal is stored for a short time without being shifted, one or more of the input samples may remain in a leaky bucket for a relatively long period. This results in noticeable 'dips' in the trace. For this reason, the signal level has been boosted (by means of the modifications listed in Table 2). The dips are now reduced, relative to the signal, to the point were they are no longer a nuisance.

For the same reason it is advisable, if triggering is not required, to select the 'free run' position (e.g. when measuring DC voltages). Since the timebase then runs continuously, the contents of the memories are refreshed right up to the point where the display cycle starts, giving the best results.

Litterature:
Elektor, May 1978, P.5-20: 'TV scope using bucket-brigade memory';
Elektor, October 1978:

- *page 10-03: 'an introduction to the TV scope';*
- *page 10-30: 'TV scope, basic version';*
- *page 10-27: 'VHF/UHF TV modulator';*
- *page 10-44: 'analogue reverberation unit';*

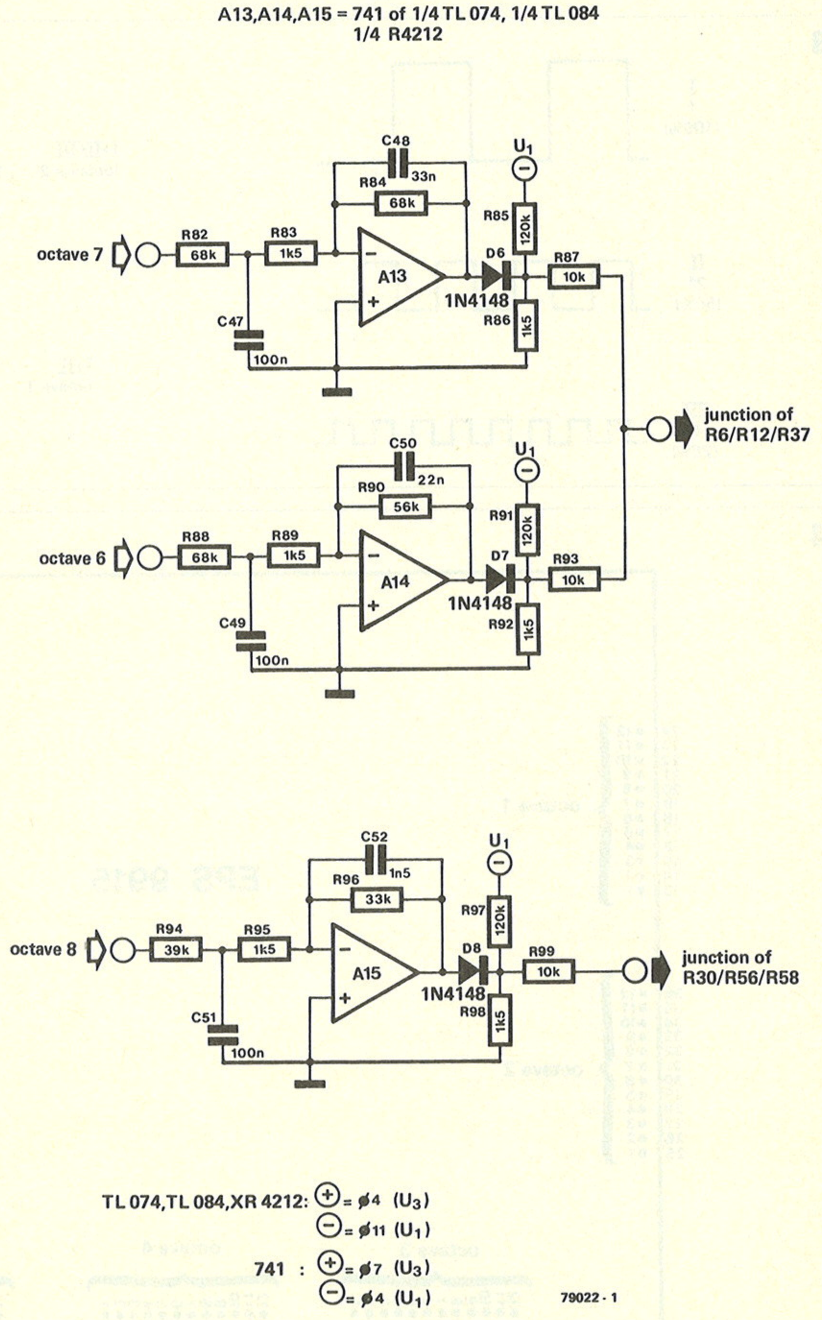
Elektor, November 1978, page 11-25: 'extending the TV scope'.



extending the elektor piano

Although the compass of the Elektor piano which was published in September of this year (Elektor No. 41) originally covered only five octaves, it was stated then that thanks to its modular design, it could be easily extended to span 6, 7 or even 8 octaves. Judging by the reaction from our readers, it does in fact appear that there is a considerable interest in an electronic piano with a full 8-octave compass, i.e. ninety-six keys and a fundamental frequency range extending from 17.4 to 4148 Hz. For this reason the following short article provides readers with details of the changes in component values and of the additions to the filter circuits which will be required to extend the compass of the Elektor piano.

1



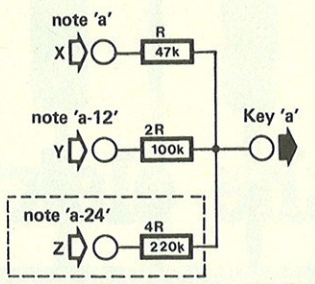
Firstly there is the question of the values of the discharge resistors R1 through R12 on the extra octave boards (EPS 9981). For the highest octave, i.e. octave 8, R1 through R6 = 100 k, and R7 through R12 = 120 k. For octave 6, the second *lowest* octave, R1 through R6 = 1 M, and R7 through R12 = 1M2, whilst for octave 7, the lowest octave, R1 through R6 = 1M5, and R7 through R12 = 1M8.

The original board layout for the filter circuits (EPS 9981) was designed for the 5-octave version. Thus, depending on however many extra octaves are required, it will be necessary to incorporate one or more of the additional filter circuits shown in figure 1. These will, of course, have to be mounted on, e.g. a small piece of Veroboard, and housed in the vicinity of the filter board proper.

This seems a useful opportunity to mention an interesting possibility for those readers who, without wishing to redesign the voicing circuits, might like to experiment with altering the sound of the original piano. The following tip has been received from a Dutch reader, a Mr. Hulshoff from Rotterdam, who recommends introducing even harmonics (the second, fourth, sixth harmonic etc. of the fundamental) into the squarewave outputs of the master tone generator, which being symmetrical, are presently composed only of the fundamental and a number of odd harmonics.

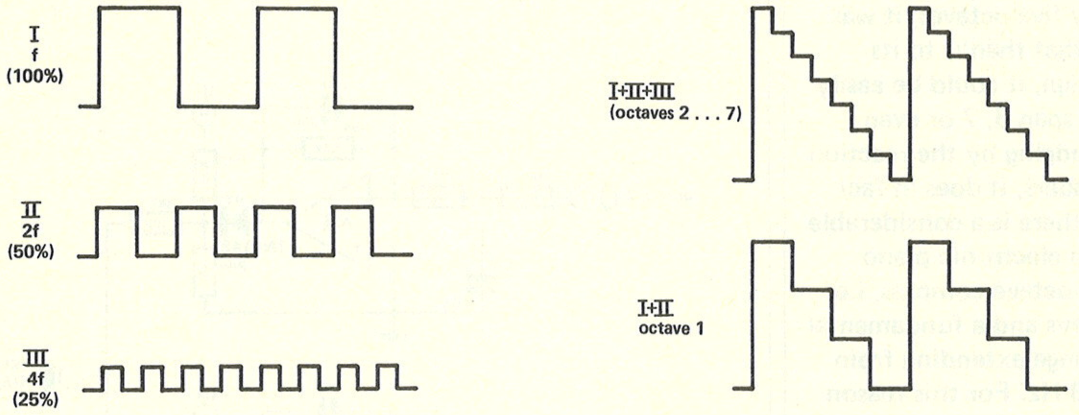
With the aid of the resistor network shown in figure 2, the master tone generator outputs are not fed straight to the corresponding inputs of the keying circuits; rather they are summed with one, or in most cases, two squarewave signals which successively have twice the frequency but half the amplitude of the

2



79022 3

3



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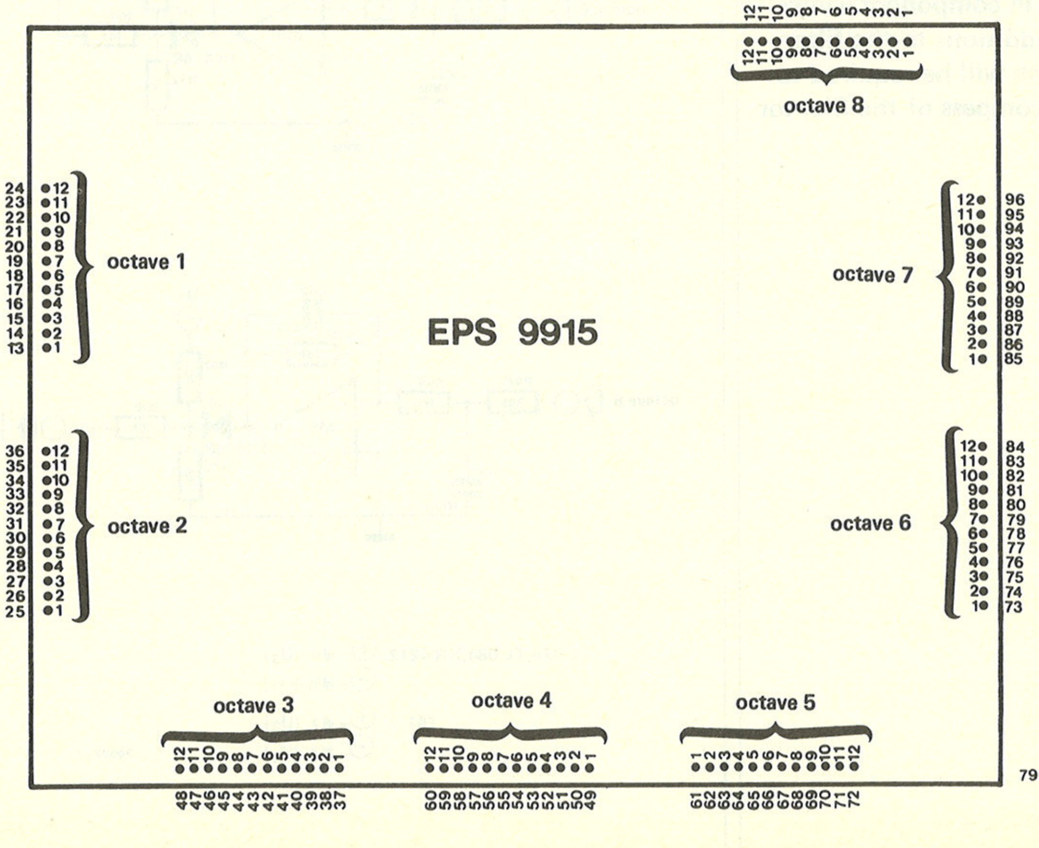
4

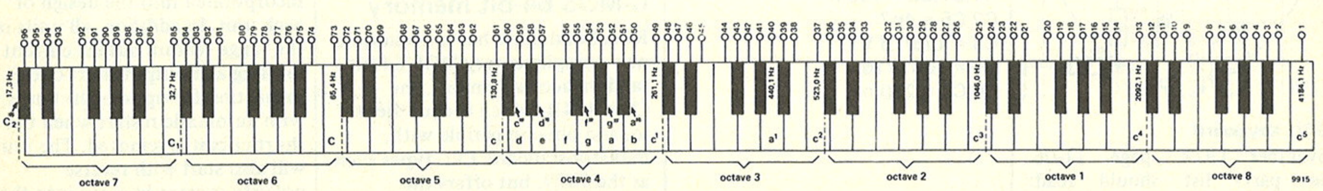


79022 4

key number	number . . .	of octave . . .	X	Y	Z
1	1	8	—	—	—
2	2	8	—	—	—
3	3	8	—	—	—
4	4	8	—	—	—
5	5	8	—	—	—
6	6	8	—	—	—
7	7	8	—	—	—
8	8	8	—	—	—
9	9	8	—	—	—
10	10	8	—	—	—
11	11	8	—	—	—
12	12	8	—	—	—
13	1	1	13	1	—
14	2	1	14	2	—
15	3	1	15	3	—
16	4	1	16	4	—
17	5	1	17	5	—
18	6	1	18	6	—
19	7	1	19	7	—
20	8	1	20	8	—
21	9	1	21	9	—
22	10	1	22	10	—
23	11	1	23	11	—
24	12	1	24	12	—
25	1	2	25	13	1
26	2	2	26	14	2
27	3	2	27	15	3
28	4	2	28	16	4
29	5	2	29	17	5
30	6	2	30	18	6
31	7	2	31	19	7
32	8	2	32	20	8
33	9	2	33	21	9
34	10	2	34	22	10
35	11	2	35	23	11
36	12	2	36	24	12
37	1	3	37	25	13
38	2	3	38	26	14
39	3	3	39	27	15
40	4	3	40	28	16
41	5	3	41	29	17
42	6	3	42	30	18
43	7	3	43	31	19
44	8	3	44	32	20
45	9	3	45	33	21
46	10	3	46	34	22
47	11	3	47	35	23
48	12	3	48	36	24
49	1	4	49	37	25
50	2	4	50	38	26
51	3	4	51	39	27
52	4	4	52	40	28
53	5	4	53	41	29
54	6	4	54	42	30
55	7	4	55	43	31
56	8	4	56	44	32
57	9	4	57	45	33
58	10	4	58	46	34
59	11	4	59	47	35
60	12	4	60	48	36
61	1	5	61	49	37
62	2	5	62	50	38
63	3	5	63	51	39
64	4	5	64	52	40
65	5	5	65	53	41
66	6	5	66	54	42
67	7	5	67	55	43
68	8	5	68	56	44
69	9	5	69	57	45
70	10	5	70	58	46
71	11	5	71	59	47
72	12	5	72	60	48
73	1	6	73	61	49
74	2	6	74	62	50
75	3	6	75	63	51
76	4	6	76	64	52
77	5	6	77	65	53
78	6	6	78	66	54
79	7	6	79	67	55
80	8	6	80	68	56
81	9	6	81	69	57
82	10	6	82	70	58
83	11	6	83	71	59
84	12	6	84	72	60
85	1	7	85	73	61
86	2	7	86	74	62
87	3	7	87	75	63
88	4	7	88	76	64
89	5	7	89	77	65
90	6	7	90	78	66
91	7	7	91	79	67
92	8	7	92	80	68
93	9	7	93	81	69
94	10	7	94	82	70
95	11	7	95	83	71
96	12	7	96	84	72

N.B. 1 A standard upright piano keyboard extends from key 4 up to and including key 88.

N.B. 2 The shaded section of the table covers those keys included in the 5-octave version of the piano.



original squarewave. As figure 3 clearly shows, the result is a staircase waveform which has a high proportion of even harmonics. (Obviously, in the case of octave 1, i.e. the second highest octave, it is only possible to sum the corresponding master tone generator outputs with *one* signal of twice the frequency, i.e. that of octave 8 – the highest octave, whilst in the case of octave 8 itself, the above procedure is impossible).

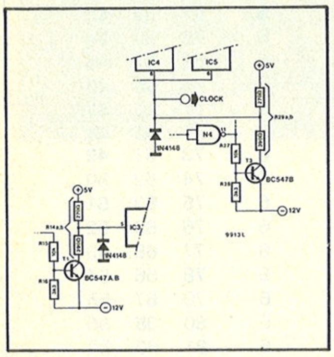
The connection points X, Y and Z, for the resistor network of figure 2 are given in the accompanying table. As is apparent, each note is accorded both a key number (a procedure which was necessary to simplify the figure on page 9-10, Elektor 41), an octave number (1 . . . 8) and a number which indicates its position in the octave.

Finally, to prevent any lingering confusion figure 4 once more shows the component layout of the board for the master tone generator. As most readers soon spotted the original layout on page 9-11 of Elektor 41 transposed the indications for notes 1 to 12 on all but octave 4. However this fault does not appear on the actual boards. ◼

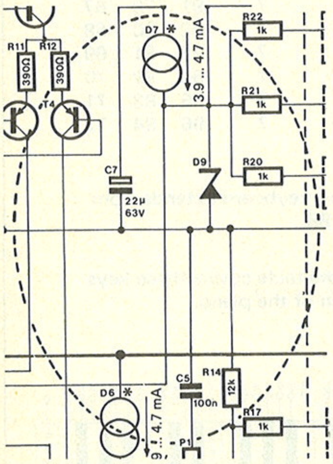
missing link

Modifications to
Additions to
Improvements on
Corrections in
Circuits published in Elektor

Digital reverberation unit
Elektor 37, May 1978, p. 5-08. Three possible pin-compatible equivalents are listed for the 1024-bit shift register. However, when using the MM5058 the dissipation may in some cases be on the high side. The reason for this is the clock pulse level: 12 V top-top, whereas this particular IC is quite happy with only 5 V. A simple circuit modification (only required if the MM5058 is used!) is given below.



FET audio amplifier
Summer Circuits 1978, circuit no. 39. Components C5, C7, R14 and D9 are shown in the circuit as connected to supply common. However, they should be connected to the R7/R25 junction, as shown in the diagram below.



ASCII keyboard
November 1978, page 11-06. The parts list should read: R1 = 680 k; R2 = 100 k. The keyboard switches are listed as type MM9; the full type number is MM9-2. In Table 3, the last few lines are incorrect. The corrected section of the table is given below.

CTL + M = CR (CARRIAGE RETURN) = CR + erasure to end of line
CTL + H = BS (BACK SPACE) = cursor ←
CTL + [= ESC (ESCAPE) = scroll up
CTL +] = CR (carriage return) without erasure
CTL + Z = SUB = erasure of current line
↖ = FS (FILE SEPERATOR) = home cursor

CMOS FSK modulator
Summer Circuits 1978, circuit no. 72. The reset connection of the 4020 (IC1) should be connected to supply common, instead of to positive supply.

Master tone generator
September 1978, page 9-09. The M 087 is an SGS/ATES type; not Motorola, as stated in the article. Our apologies for any inconvenience this may have caused.

Databus buffer
October 1978, page 10-18. On the component layout (figure 3) the '+' and '0' supply connections are transposed: the '+' connection runs along the outer edge of the board to pins 20 of IC1 and IC2.

Tag!
November 1978, page 11-12. P3 should be a 2k2 (or 2k5) linear potentiometer.

Ring the bell and win a prize!
November 1978, page 11-22. The output voltage U_p, referred to at several points in the text, is present at the emitter of T2 (point 'M'). Furthermore, the component numbers given in the parts list are incorrect; the corrected list reads:

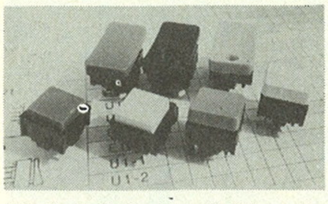
Resistors:
R1,R4,R19,R20,R22 = 10 k
R2,R8,R9,R10,R12,
R17,R21 = 100 k
R3 = 33 k
R5,R6 = 2k2
R7 = 220 k
R11,R14,R15 = 1 k
R13 = 180 k
R16,R18 = 15 k
R23 = 220 Ω
P1,P3,P4 = 100 k preset
P2 = 10 k lin

Capacitors:
C1,C7,C8 = 100 n
C2,C5 = 4n7
C3 = 1µ5/16 V
C4 = 100 µ/16 V
C6,C9 = 220 n

MARKET

Mini push button switches

A range of miniature snap-action push button switches, designed for printed circuit board mounting on a 0.1 inch (2.54 mm) hole grid, is now available from Impectron Ltd. Switches in the Petrick 320 range feature attractive, ergonomically designed faces and a positive snap or rocker action. Single pole press-to-break and changeover configurations are all available as standard, and an LED indicator can be incorporated to provide visual warning of function selected.



The basic body size of all types is 12.4 x 12.4 x 7.5 mm (approx. 0.5 x 0.5 x 0.3 inches) with 4 mm (0.16 in) long connection tags. The selected push button or rocker action will add a further 5 mm to body depth. This space saving design allows very compact keyboards and control panels to be constructed economically. Switches may also be mounted in line or block format to form key sets with mechanical interlocking and release mechanisms.
Despite their small size the switches are capable of handling up to 25 mA at 50 V DC. Contact resistance is less than 20 milliohms and operational life is in excess of 10^5 operations at full load. Operating temperatures range is −25° to +75°C.

Impectron Limited,
Impectron House,
23-31 King Street,
London W3 9LH

(984 M)

C-MOS 64-bit memory

RCA Solid State has introduced a new complimentary MOS 64-bit random-access memory, the CD40114B, which is equivalent to, and pin-compatible with, industry-standard TTL types such as the 7489, but offers the additional C-MOS advantages of low power consumption, high noise immunity and wide supply voltage range (20 V rating). The CD40114B is equivalent to the C-MOS type 74C89.
The CD40114B is a 16-word x 4-bit random-access memory with four address inputs, four data inputs a 'write-enable' input, a 'memory-enable' input, and four 3-state data outputs. The memory-enable input and the 3-state data outputs allow memory expansion, and the four address inputs are decoded internally to select one of the 16 possible word locations.
An input address latch facility is included; the address information is latched on the negative edge of the memory-enable input by an internal address register. The selected output assumes a high-impedance condition when the device is writing or disabled.

RCA Solid State,
Sunbury-on-Thames,
Middlesex, TW16 7HW

(981 M)

DC/DC converters

Gresham Lion Limited have added a further series of miniature encapsulated DC/DC converter units to its popular GEMINI range. Designated the Gemini 800 Series, the new additions will extend the existing range by 24 units, making it one of the most comprehensive currently available.

The 800 series consists of 16 single output and eight dual output Converters operating from nominal DC inputs of 5, 12, 24 or 28 volts. Designed to operate over wide input voltage ranges, these 10 and 12 watt units provide excellent line/load regulation and high efficiency (65% typical) even with output loads as low as 10% of rated output.
All models employ Pi-type input filters to minimize reflected input ripple current. EMI/RFI protection is provided through complete six-sided continuous shielding incorporated into the design of each unit. In addition, all units in the range feature output current limiting and output short-circuit protection for up to eight hours, with automatic restart when the short circuit is removed. The units will also start with reverse polarity current injected into the output. The units are designed for PCB mounting, they measure 89 x 63 x 22 mm (3.5 x 2.5 x 0.88 inches) (L x W x H), and will operate in the temperature range −25 to +71°C.

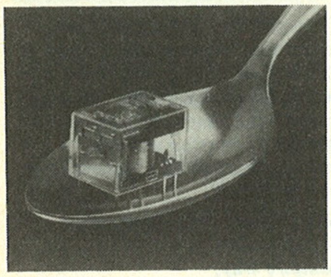
Gresham Lion Ltd.,
Gresham House,
Twickenham Road,
Feltham, Middlesex.

(927 M)

MARKET

Subminiature Relay

One of the world's smallest relays, the G2E, is available with coil ratings from 1.5 V to 24 V at currents of 18.8 mA to 300 mA. This subminiature component measures only 16 x 11 x 10.5 mm and weighs just 3.5 g. Features include long service life, in excess of 5 x 10^6 operations, and a switching frequency of 1800/hr max. Coil resistances range from 5 Ω to 1280 Ω and this highly sensitive relay requires only 290 mW of pull-in power. Both operate and release times are ≯ 5 ms, and the G2E has an insulation resistance of ≮ 100 MΩ (measured with a DC 500 V megger).



Designed specifically for p.c.b. use, the relay has its pins set on the international 2.5 mm grid terminal arrangement. A transparant case protects the component from dust, while the operating ambient temperature range is –25°C to +55°C. Relay contacts are rated at 0.5 A (100 V AC PF = 1) or 1 A (24 V DC), while the carry current is 2 A for both versions.

IMO Precision Controls Limited,
349 Edgware Road,
London W2 1BS

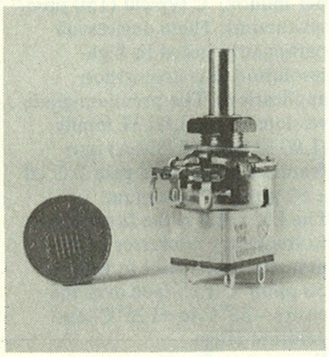
(973 M)

23 mm potentiometers with switch

The new Iskra 23 mm carbon potentiometers are spindle-operated and incorporate a switch rated at 250V AC, 4 A continuous current, 80 A surge current. Known as the P8SL series, they are available from Iskra Limited of Coulsdon, Surrey, the British trading subsidiary of the multinational Iskra organisation.

Each switch is approved to BS415 and SEMKO standards, and the series is produced in both linear and log values. The linear values extend from 100 ohms to 10 megohms, and the log values from 2.5 kilohms to 5 megohms. Maximum voltages which can be applied to the carbon track are: linear units, 500 V DC; log units, 350 V DC.

All potentiometers in the P8 range can be supplied with any one of three tappings – 40%, 50% or 60%. Each unit has a 295-degree angle of rotation and a smooth rotary action. End-stop torque is 8 kgcm.



Low-noise carbon-brush wipers are standard throughout the range. Rated dissipations are 0.4 watts (linear) and 0.2 watts (log). Mechanical fixing is by a standard M10 x 0.75 mm screw thread. Two mounting styles are available, one standard and one special. The standard is designed for a 10.1 mm diameter centre hole, with a 2.1 mm (+0.1 mm, –0 mm) locating hole. On special request, Iskra can supply units for mounting in a 10 mm diameter hole with a rectangular section extending from the circumference. This section measures 2.5 mm x 2.6 mm (+0.1 mm, –0 mm).

Dual-gauged versions for stereophonic applications are also available.

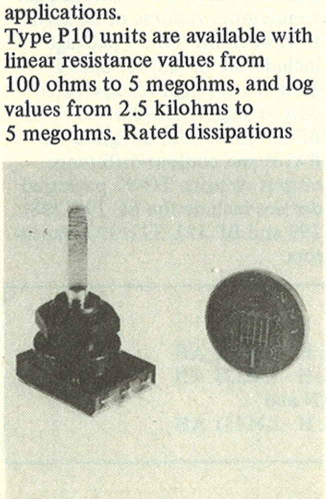
Iskra Limited,
Redlands, Coulsdon,
Surrey, CR3 2HT

(986 M)

16.8 mm carbon potentiometers

There are four types in this new 16.8 mm spindle-operated range, and together they cover many applications.

Type P10 units are available with linear resistance values from 100 ohms to 5 megohms, and log values from 2.5 kilohms to 5 megohms. Rated dissipations are 0.15 watts (linear) and 0.08 watts (log). Designed for mounting with a M7 x 0.75 mm screw, all P10 potentiometers incorporate a metal contact wiper. Angle of rotation is approximately 295 degrees, and all units have a smooth rotary action. End-step torque is equal to or greater than 4 kgcm.



All potentiometers in the P10 range are available with an integral switch rated at 12 V, 2 A. When a switch is incorporated, the type number is designated P10S.

For stereo hi-fi and similar applications, Iskra has produced a tandem version of the P10. Called the P10T, it has the same specification as other units in the P10 range. Matching can be achieved down to 26 dB.

16.8 mm series with plastic cases

Many applications today demand a higher resistance to the ingress of dust and other harmful particles. To cater for this demand, Iskra Limited has introduced a series of plastic-cased potentiometers. Known as the P11P series, these 16.8 mm spindle-operated carbon units are specifically designed for printed-circuit applications, but are also available with solder terminations. As well as featuring a plastic case, all P11P units have a 4 mm plastic spindle and a plastic threaded sleeve (M10 x 0.75 mm). Resistance values are 100 ohm to 5 megohms linear, and 2.5 kilohms to 5 megohms log. The angle of rotation is approximately 270 degrees. Each P11P potentiometer has a smooth rotary action, and an end-stop torque of 4 kgcm. Rated dissipations are 0.15 W linear, and 0.08 W log.

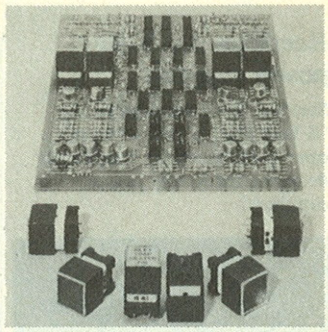
Iskra Limited,
Redlands, Coulsdon,
Surrey, CR3 2HT

(987 M)

P.C.B. mounted illuminated push-button switches

Highland announce the release of Series 99 illuminated push-button switches and indicators for printed-circuit-board mounting. Designed for applications on both industrial and domestic equipment, this new range has low-level switching elements rated 100 mA, 50 V max. Push buttons and indicator assemblies are square – screen size 18.6 mm square with both flat and concave illuminated screens.

The switch and indicator terminations are by 1 mm pins for direct p.c. board mounting. They may be flow soldered. Illumination is provided by miniature T1 size bi-pin lamps available in 6, 12, 18, 24, 28 and 36 Volt versions.



The range comprises Indicators (signal lamps) and both momentary and maintained-action switches with low-level switching elements having a 1 make/1 break (non-shorting) contact configuration.

Film legends, designed and produced to customer's requirements by Highland, are intended for use on Series 99 devices. These are sandwiched between the clear outer screen and the inner white diffusor with a colour backing film if required.

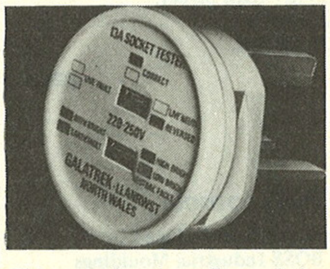
Highland Electronics Ltd.,
Highland House, 8 Old Steine,
Brighton, East Sussex, BN1 1EJ

(988 M)

The plug which thinks for itself

This ingenious three pin 13 amp plug by means of neons and indicator on the front of the plug shows immediately if:

1. Socket is A1 OK
2. DANGER reverse polarity
3. DANGER no earth
4. DANGER live fault
5. DANGER neutral fault



This tester is universally needed by DIY buffs, craftsmen, tradesmen, householders, installers of microwave and solid state circuitry and throughout industry and commerce. It was initially designed to protect electronic machinery installed by C. & A. Modes in all their stores throughout the U.K.

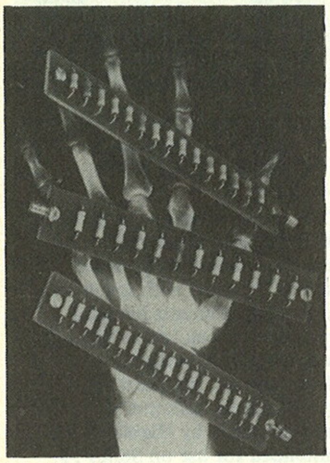
Galatrek Engineering,
Scotland Street, Llanrwst,
Gwynedd, LL26 0AL,
North Wales, Great Britain.

(975 M)

MARKET

Rectifiers for X-Ray power supplies

Semtech have introduced the 'X-Way Stic', a new series of open rectifier sticks specifically designed for X-Ray power supplies.



Each X-Way utilizes hermetically sealed 'Metoxilite' multi-chip 'avalanche' rectifiers mounted on a PCB. These 'Metoxilite' multi-chip rectifiers (initially developed for high reliability aerospace programmes) are now available at commercial prices.

In addition to X-Ray power supplies, these rectifiers can be efficiently used in most standard, single and polyphase circuits.

Type: X 100KS, X 125KS,
X 150KS.
PIV : 100, 125, and 150 KV.
Average Rectified Current (at 55°C oil): 220 mA.
Size : (overall) 6.22"L x .690"W x (end cap) .500"D (anode) .390"L.

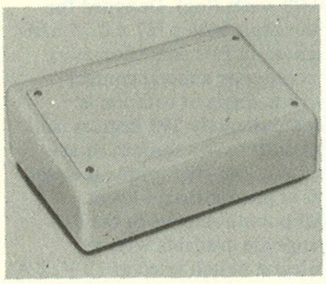
Bourns (Trimpot) Limited,
Hodford House,
17/27 High Street,
Hounslow,
Middlesex.

(926 M)

Desk console

Recently introduced by BOSS Industrial Mouldings Limited is the new BIM 8005 Small Desk Console, the main feature of which is its three piece construction which allows rapid and easy removal of both top and bottom panels.

The main body of the console is manufactured in ABS, as is also the removable bottom panel which incorporates 9 mounting bosses for supporting either a full 100 x 160 mm Eurocard or 2 half size boards.



The flush mounted 1 mm thick grey aluminium top panel tones with the orange, black or blue console body, the latter – as with the majority of BOSS enclosures – also incorporating slots for vertically mounting 1.5 mm thick pcb's as well as the recently announced BIMDAPTORS which allow pcb's to be mounted sandwich fashion.

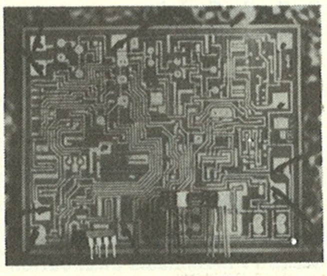
Measuring internally 165 x 122 x 60 mm high and incorporating small, self adhesive, rubber stand-off feet on the base, this new small desk BIMCONSOLE is equally suited to initial development, pre-production and OEM type applications.

BOSS Industrial Mouldings Ltd,
Higgs Industrial Estate,
2 Herne Hill Road,
London, SE24 OAU, England

(921 M)

Voltage-to-frequency converters

A new family of Voltage to Frequency (V-To-F) converters, designated LM131/231/331 is now available from National Semiconductor Corporation, with better specifications than any previous device.



It is claimed that the new devices all function with guaranteed 0,01% maximum non-linearity as 10 KHz V-to-F or F-to-V converters, and can be operated from a single +4.0 to +40 volt power supply.

The standard device is available with a gain temperature coefficient (T.C.) of 150 parts per million/°C typical (150 ppm/° maximum). These devices are particularly suited to high-resolution data acquisition applications. The premium-grade versions of the LM131 family (LM131A/231A/331A) also feature a guaranteed gain T.C. of ± 50 ppm/°C maximum.

The LM 131A is the first voltage to frequency converter in the industry guaranteed to have a 50 ppm/°C T.C. spec over the entire −55°C to +125°C temperature range.

Designed to function as an improved, pin for pin replacement for the 4151 V-to-F converter, the LM131 is specified to operate over its 4 to 40 volt supply range with improved accuracy.

The LM131 also features low power dissipation (14 milliwatts) when operated from +5 volt supplies, and this is highly suitable for battery powered applications.

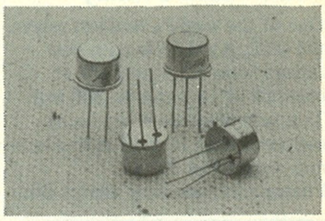
National Semiconductor,
301 Harpur Centre, Horne Lane,
Bedford MK40 1TR.

(909 M)

Temperature range	
−55° to 125°C	LM131 H - LM131 AH
−25° to +85°C	LM231 H - LM231 AH
0° to +70°C	LM331N and LM331 H - LM331 AH

High-voltage video transistors

Micro Electronics Ltd. has introduced a wide range of high-voltage n-p-n silicon planar transistors designed for video-amplifier applications in colour and monochrome television receivers. Available in TO-39 and TO-92 cases, the devices feature collector-emitter breakdown voltages up to 300 V and have good frequency characteristics, with current-gain bandwidth products of 50 MHz. Devices in the TO-39 package include the BF 257/258/259, designed for high-voltage video output stages, and the BF 336/337/338, designed for R-G-B and coulour-difference output circuits. TO-92 packaged devices include the BF 297/298/299 and BF 391/392/393 transistors.



The devices are designed for maximum emitter-base voltage of 5 - 8 V, and cover maximum collector currents from 100 mA to 500 mA. Total maximum power dissipation at a case temperature of 25°C ranges from 1.5 W to 5 W.

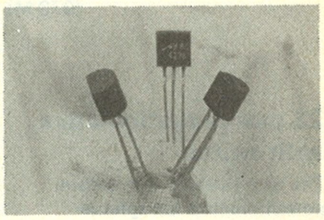
Micro Electronics Limited,
York House,
Empire Way,
Wembley, Middlesex.

(918 M)

Low-noise audio transistors

A new range of small-signal transistors from Micro Electronics Ltd. are designed for low-noise preamplifier, audio-frequency amplifier driver stages and signal-processing circuits in television receivers. Designated the BC 413/414/415/416 Series, the transistors are low-cost silicon planar epitaxial devices featuring high breakdown voltage, high gain and low flicker noise.

The BC 413 and BC 414 are n-p-n transistors, while the BC 415 and BC 416 are the complementary p-n-p devices.



Maximum collector-base voltage is 45-50 V, maximum emitter-base voltage 5 V. Maximum continuous collector current is 100 mA, and total power dissipation is 300 mW.

Current gains ranging from 125 up to 900 are available, typical noise figure is 1.2 dB, and flicker-noise voltage referred to base is only 0.11 μV for the BC 415 and BC 416 and 0.135 μV for the BC 413 and BC 415.

Micro Electronics Limited,
York House,
Empire Way,
Wembley, Middlesex.

(930 M)

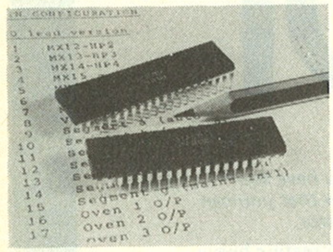
MARKET

µP appliance timer

A single package MOS-LSI microcircuit appliance timer, consisting of a central processor with on-chip memory, has been introduced by General Instrument Microelectronics. The circuit – basically a 4-bit microprocessor – is available as a basic 28-lead or a more sophisticated 40-lead version, and will considerably widen the scope of domestic appliance designers.

The device is essentially a versatile, low cost timer, providing designers with the type of facilities necessary for controlling cookers, driers, central heating, etc. The 28-lead version designated AY-3-1250, accepts instructions from 'hours up', 'hours down', 'minutes up', or 'minutes down' keys, where momentary depression of keys cause single increments or decrements, and continuous depression causes the displayed digits to cycle. In use the circuit is linked to a 4-digit LED display indicating any function selected. It has 3 separate outputs for which on and off times may be programmed in.

In a cooker application, all normal instructions may be programmed in, including ON time, OFF time, cook duration, etc. Other facilities include a 'minute minder' with audible alarm output, indication of mains failure, 12/24 hour operation, temperature setting or an optional fluorescent display driver output interface.



The 40-lead version – designated AY-3-1251 – is designed for more sophisticated systems where 10 x 4 keyboard or touchpad entry and 14-digit permanent display are required. It has four controlled outputs, each with a variable mark-space ratio for control of hotplate duty cycles, etc. The 14-digit display facility could be used for a minute minder (3 digits), oven temperatures (3 digits), time on/off (4 digits), and hotplate temperature (4 digits).

When used for fully automatic cooker control, the time programme would be entered and cooking temperature selected using a key pad. When the start time is reached the appropriate output would be activated and an 'ON' indicator lamp energised. When the stop time is reached the output is deactivated and the minute minder audible alarm activated for 10 seconds. All 3 programmable outputs may be separately controlled in this way, but the device can also be used in a semi-automatic or manual mode. A further facility allows a set programme to be repeated at 24 hour intervals by the simple depression of a 'repeat' key.

Both 28-lead and 40-lead versions include a built-in standby frequency source, which allows the devices to function normally during mains failure. In this event the circuit detects the abscence of 50/60 Hz input, and a 200 kHz oscillator takes over timing under external battery power and lights a 'mains failure' warning lamp. On the re-application of the mains supply the circuit returns to mains power, but leaves the lamp on (until it is manually reset) to indicate that mains failure has occured.

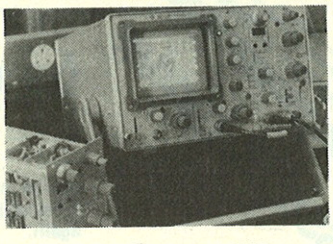
Although the two versions described here are standard devices, the microcircuit chip is mask programmable to include a wide range of options and output requirements. These include steady or pulsed temperature display outputs, error 'E' display, programmable time delays, touchpad inputs. Both versions are extremely suitable for general control applications requiring simple arithmetic, display of up to 43 digits and interfacing with analogue systems.

General Instrument
Microelectronics Ltd.,
Regency House,
1-4 Warwick Street,
London W1R 5WB, England

(982 M)

Video monitoring oscilloscope

Gould Instruments Division has won a substantial order from the British Broadcasting Corporation for the supply of an oscilloscope designed for video monitoring applications. The oscilloscope is a modified brighter version of the Gould Advance OS3300B with a BBC designed timebase module incorporating comprehensive video triggering facilities, which is being made by Gould under a manufacturing licence agreement from the BBC.



The new timebase generator allows the oscilloscope to be used for detailed line-by-line examination of 625-line television waveforms or to display a television picture. It accepts a standard level video signal, which may contain 'Sound-in-Sync' signals and provides six different triggering modes: field 1; field 2; field 1 and 2 alternating; line repetitive; single line selectable by front panel switches (with the line number indicated on a 3 digit light emitting diode display) and line pairs in the range 16/329 to 22/335.

The triggering can be delayed continuously by up to 90 µs via a multiturn potentiometer, which allows the signal to be examined in detail. The displayed video signal may be clamped or not, as required. When the unit is used to display a television picture, the triggering point selected may be observed as a 'bright up line' on the picture, enabling the waveforms to be rapidly related to the picture. The changeover from waveform to picture is effected by a single front panel switch. The modified timebase retains its normal triggering facilities, so that the instrument may be used as a general purpose single timebase oscilloscope.

Gould Instruments Division,
Roebuck Road, Hainault,
Essex

(974 M)

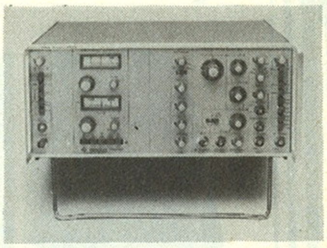
1 MHz to 1600 MHz in one sweep

Gould Instruments Division has entered the sweep-generator market with the introduction of the Gould Advance SW100, a high-performance instrument which can cover the frequency range from 1 MHz to 1600 MHz in a single, flat sweep. Other key features of the instrument include a comprehensive automatic marker system for precise frequency determination and an output level unit that can be varied in 0.01 dB steps.

The Gould Advance SW100 incorporates electronic switching between the three basic ranges (1-500 MHz, 450-1000 MHz and 950-1600 MHz) to give the effect of a single sweep. Deviation from flatness is ± 0.25 dB using a power meter, or ± 0.35 dB measured on a full-wave detector.

The three operating modes of the SW100 are: start/stop or F1/F2 mode, in which a sweep occurs from one set frequency to another; FC/ f (delta F) mode, in which a centre frequency is set in the middle of a spectrum of interest with one control and a deviation about the centre frequency is set with another control; and signal generator mode, in which the sweep drive is switched off and the sweeper is used as a straight signal generator.

An extremely accurate output attenuation system offers ten steps of 10 dB, 1 dB, 0.1 dB or 0.01 dB, and the output level range can be varied from +6.66 dBm (471 mV or 4.6 mW) to –103.33 dBm (3 µV or 0.18 pW) in 0.01 dB steps.



The SW100 incorporates a unique high-accuracy automatic harmonic marker system with frequencies of progressively increasing resolution being cut in as they are needed. Markers are provided with 100 MHz, 1 MHz and 100 kHz separations, and the markers can be oriented in horizontal, vertical or 45° directions to prevent them being obscured by the waveform under examination. A unidirectional marker facility is also provided for cases where the instrument is used with low-speed output devices such as X-Y plotters.

Internal and external amplitude and frequency modulation (both fully swept) are available, and comprehensive internal and external sweep-rate controls are incorporated. The sweep may be varied between 70 Hz (14 ms sweep) and 120 seconds per sweep. A manual sweep control is also incorporated.

Harmonic-related spurious outputs are typically –35 dB, and nonharmonic spurious outputs are less than –40 dB. Linearity is better than ± 2%.

Construction of the SW100 is based on a modular approach, with easy accessibility for servicing and maintenance, leading to low cost of ownership. Three blank panels are provided on the front panel to accommodate future options; a hard-copy output option is already available.

The Gould Advance SW100 measures 320 x 145 x 365 mm, and weighs 8.6 kg.

Gould Instruments Division,
Roebuck Road, Hainault,
Essex

(980 M)

The Elektor cassette-binder

Price £2.30 (inc
Postage and Packing) USA
and Canada $4.00

Available from Elektor Publishers Ltd.,
Elektor House, 10 Longport, Canterbury,
Kent. CT1 1PE.
(please use Elektor readers service order
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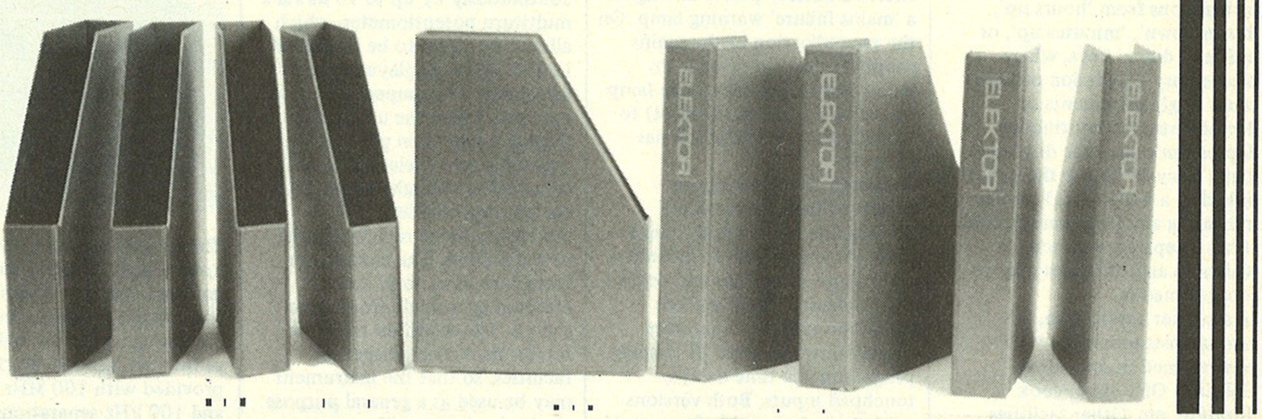
for your copies of Elektor

It is evident that in your profession and/or hobby the design ideas published in Elektor are referred to time and time again.

We are therefore now introducing this new cassette style binder to keep your copies of Elektor clean and in order.

The chamfered corner of the cassette allows instant recognition of each months issue without the need to thumb through pages of previous months issues.

No wires or fastenings are used so copies are easily removed and replaced and each cassette will hold one year's volume of Elektor. Their smart appearance will look good on any laboratory shelf.



elektor

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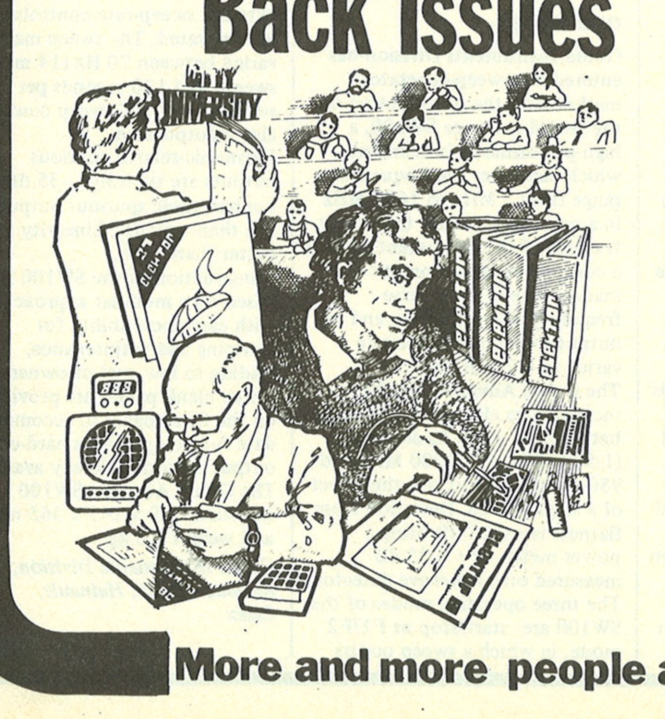

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7440	17p
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7442A	60p
7443	112p
7444	112p
7445	100p
7446A	93p
7447A	70p
7448	80p
7450	17p
7451	17p
7453	17p
7454	17p
7460	17p
7470	36p
7472	30p
7473	34p
7474	30p
7475	36p
7476	35p
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7481	100p
7482	84p
7483A	90p
7484	100p
7485	110p
7486	34p
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7490A	33p
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7492A	46p
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74LS196	120p
74LS221	100p
74LS240	175p
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74LS324	200p

74LS298	249p
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9322	150p
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9370	200p
9374	200p
9601	100p
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9603	60p

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74C42	110p
74C48	250p
74C73	75p
74C74	70p
74C85	200p
74C86	65p
74C90	95p
74C95	130p
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74C151	260p
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74C175	210p
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74C193	150p
74C194	220p
74C195	110p
74C221	175p

4000 SERIES

4000	15p
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4002	17p
4006	95p
4007	18p
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4009	40p
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4528	100p
4543	180p
4553	450p
4560	250p
4583	90p
4584	90p
40014	90p
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14411	£11
14412	£11
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SN76477N £2.50

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LINEAR ICs

AM2833	400p
*AY1-0212	600p
*AY1-1313	668p
*AY1-1320	320p
*AY1-5050	212p
*AY5-1315	600p
*AY5-1317	636p
*CA3019	80p
*CA3046	70p
*CA3048	225p
CA3080E	72p
*CA3089E	175p
*CA3090AQ	375p
CA3130S	100p
CA3140E	70p
CA3160E	75p
FX209	750p
ICL7106	925p
ICL8030	340p
LM301A	30p
LM311	120p
LM318	200p
LM324	70p
LM339	90p
LM348	95p
*LM377	175p
*LM380	75p
*LM381AN	160p
*LM389N	140p
LM709	36p
LM710	50p
LM725	350p
LM733	100p
LM741	22p
LM747	70p
LM748	35p
LM3900	70p
LM3911	130p
LM4136	120p
*MC1310P	150p
MC1458	55p
MC1495	400p
*MC1496	100p
*MC3340	120p

MC3360	120p
*MFC4000B	120p
MK50398	750p
NE531	130p
*NE540	200p
NE543K	225p
NE555	25p
NE556	70p
NE561B	425p
NE526B	425p
NE565	130p
NE566	155p
NE567	175p
*NE571	425p
RC4151	400p
SFF96364	1450p
*SN76003N	175p
*SN76013N	140p
*SN76013ND	120p
*SN76023N	140p
*SN76023ND	120p
*SN76033N	175p
*SP8515	750p
*TBA621A	225p
*TBA641B11	225p
*TBA651	200p
*TBA800	90p
*TBA810	100p
*TBA820	90p
*TCA940	175p
*TDA1004	325p
*TDA1008	325p
*TDA1022	600p
*TDA2020	320p
TL704	130p
TL084	130p
TL170	50p
XR2206	400p
XR2207	400p
XR2211	500p
*XR2216	675p
XR2240	400p
*ZN414	90p
ZN424E	135p
ZN425E	400p
ZN1034E	200p
95H90	800p

VOLTAGE REGULATORS

Fixed Plastic TO-220

1A	+ve		−ve	
5V	7805	90p	7905	100p
12V	7812	90p	7912	100p
15V	7815	90p	7915	100p
18V	7818	90p	7918	100p
24V	7824	90p	7924	100p
100mA		TO-92		
5V	78L05	35p	79L05	80p
12V	78L12	35p	79L12	80p
15V	78L15	35p	79L15	80p

OTHER REGULATORS

LM309K	135p	TBA625B	120p
LM317T	200p	TL430	65p
LM323K	625p	78H05KC	675p
LM723	37p	78MGT2C	135p

OPTO-ELECTRONICS

2N5777	45p	ORP12	90p	ORP61	90p
OCP71	130p	ORP60	90p	TIL78	70p

LED	0.125"			0.2"	
TIL32	I.R.	75p	TIL220	Red	16p
TIL209	Red	13p	TIL222	Gr	18p
TIL211	Gr	20p	TIL228	Red	22p
TIL212	Ye	25p	MV5491 TS		120p
TIL216	Red	18p	Clips		3p

DISPLAYS

			FND500	120p
			FND507	120p
DL707	Red	140p	TIL311	600p
707	Gr	140p	TIL312/3	110p
DL747	Red	225p	TIL321/2	130p
747	Gr	225p	TIL330	140p
FND357		120p		

TRANSISTORS

AC127/8	20p
AD149	70p
AD161/2	45p
BC107/8	11p
BC109	11p
*BC147/8	9p
*BC149	10p
*BC157/8	10p
*BC159	11p
*BC169C	12p
*BC172	12p
BC177/8	17p
BC179	18p
*BC182/3	10p
*BC184	11p
BC187	30p
*BC212/3	11p
*BC214	12p
BC461	36p
BC477/8	30p
*BC516/7	50p
*BC547B	16p
*BC548C	16p
*BC549C	18p
*BC557B	16p
*BC559C	18p
BCY70	18p
BCY71/2	22p
BD131/2	50p
BD242	50p
BDY56	200p
BF200	32p
*BF244B	35p
*BF256B	70p
BF257/8	32p
BF259	36p
*BFR39	30p
*BFR40	30p
*BFR41	30p
*BFR79	30p
*BFR80	30p
*BFR81	30p
BFX29	30p
BFX30	34p
BFX84/5	30p
BFX86/7	30p
BFX88	30p
BFW10	90p

BFY50	22p
BFY51/2	22p
BFY56	33p
BFY90	90p
BLY83	700p
BRY39	45p
BSX19/20	20p
*BU105	190p
*BU108	250p
*BU205	200p
*BU208	240p
*BU406	145p
MJ481	175p
MJ491	200p
MJ2501	225p
MJ2955	100p
MJ3001	225p
*MJE340	65p
MJE2955	100p
MJE3055	70p
*MPF102	45p
*MPF103/4	40p
*MPF105/6	40p
*MPSA06	30p
*MPSA12	50p
*MPSA56	32p
*MPSU06	63p
*MPSU56	78p
OC28	130p
OC35	130p
*R2008B	200p
*R2010B	200p
*TIP29A	40p
*TIP29C	55p
*TIP30A	48p
*TIP30C	60p
TIP31A	58p
TIP31C	62p
TIP32A	68p
TIP32C	82p
TIP33A	90p
TIP33C	114p
TIP34A	115p
TIP34C	160p
TIP35A	225p
TIP35C	290p
TIP36A	270p
TIP36C	340

TIP41A	65p
TIP41C	78p
TIP42A	70p
TIP42C	82p
TIP2955	78p
TIP3055	70p
*TIS43	34p
*TIS93	30p
* ZTX108	12p
*ZTX300	13p
*ZTX500	15p
*ZTX502	18p
*ZTX504	30p
2N457A	250p
2N696	35p
2N697	25p
2N697	45p
2N706A	20p
2N708A	20p
2N918	45p
2N930	18p
2N1131/2	20p
2N1613	25p
2N1711	25p
2N2102	60p
2N2160	120p
2N2219A	20p
2N222A	20p
2N2369A	16p
2N2484	30p
2N2646	50p
2N2904/5	25p
2N2906A	24p
2N2907A	30p
*2N2926	9p
2N3053	20p
2N3054	65p
2N3055	48p
2N3442	140p
2N3553	240p
*2N3565	30p
*2N3643/4	48p
*2N3702/3	12p
*2N3704/5	12p
*2N3706/7	12p
*2N3708/9	12p
2N3773	300p
*2N3819	25p

*2N3820	50p
2N3823	70p
2N3866	90p
*2N3903/4	18p
*2N3905/6	20p
*2N4036	65p
*2N4058/9	12p
*2N4060	12p
*2N4061/2	18p
*2N4123/4	22p
*2N4125/6	22p
*2N4289	20p
*2N4401/3	27p
2N4427	90p
*2N4871	60p
*2N5087	27p
*2N5089	27p
*2N5172	27p
2N5179	27p
2N5191	83p
2N5194	90p
*2N5245	40p
*2N5296	55p
*2N5401	50p
*2N5457/8	40p
*2N5459	40p
*2N5460	40p
*2N5485	44p
*2N6027	48p
2N6247	190p
2N6254	130p
2N6290	65p
2N6292	65p
3N128	120p
3N140	100p
3N201	110p
3N204	100p
40290	250p
40360	40p
40361/2	45p
40364	120p
40408	70p
40409	65p
40410	65p
40411	300p
40594	97p
40595	105p
40603	58p
40673	75p
40841	90p
40871/2	90p

DIODES

*BY127	12p
*OA47	9p
*OA81	15p
*OA85	15p
*OA90	9p
*OA91	9p
*OA95	9p
*OA200	9p
*OA202	10p
*IN914	4p
*IN916	7p
*IN4148	4p
IN4001/2	5p
IN4003/4	6p
IN4005	6p
IN4006/7	7p
IN5401/3	14p
IN5404/7	19p

*ZENERS

2.7V — 33V

400mW	9p
1W	15p

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SPST	51p
SPDT	53p
DPDT	55p
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Push to break Black	35p

CRYSTALS

100KHz	300p
1 MHz	370p
3.2768MHz	350p
18MHz	300p

BRIDGE RECTIFIERS

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*1A	100V	22p
*1A	400V	30p
*2A	50V	30p
*2A	100V	35p
*2A	400V	45p
*3A	200V	60p
*3A	600V	72p
*4A	100V	95p
*4A	400V	100p
6A	50V	90p
6A	100V	100p
6A	400V	120p
10A	400V	200p
25A	400V	400p

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3A	400V	60p
3A	500V	65p
6A	400V	70p
6A	500V	88p
8A	400V	75p
8A	500V	95p
12A	400V	85p
12A	500V	105p
16A	400V	110p
16A	500V	130p
T2800D		130p

THYRISTORS

1A	50V	40p
1A	400V	65p
1A	600V	70p
3A	400V	90p
8A	600V	200p
12A	400V	160p
16A	100V	160p
16A	400V	180p
16A	600V	220p
BT106		110p
C106D		45p
*MCR101		36p
2N3525		120p
2N4444		140p
*2N5060		34p
*2N5064		40p

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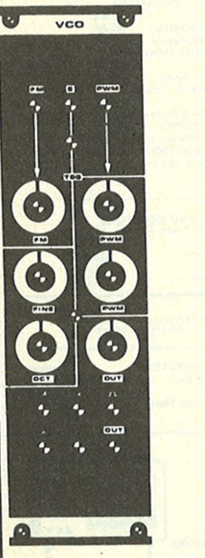

FORMANT

KEYBOARD INTERFACE (June 1977):
Set of resistors, capacitors, semiconductors and potentiometers: .... KIT 66-1 £11.19
PCB for above: .... PCB 9721-1 £2.31

GATE PULSE DETECTOR & DISTRIBUTOR, AND DIVIDER NETWORK (Sept 1977:)
Set of resistors, capacitors, semiconductors, and potentiometers: .... KIT 66-2 £5.42
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POWER SUPPLY (Sept 1977):
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PCB for above: .... PCB 9721-3 £3.69

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Set of resistors, capacitors, semiconductors, and potentiometers: .... KIT 66-4 £28.05
PCB for above: .... PCB 9723-1 £7.38

VOLTAGE CONTROLLED FILTER (Dec 1977):
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PCB for above: .... PCB 9724-1 £3.03

VOLTAGE CONTROLLED AMPLIFIER (Feb 1978):
Set of resistors, capacitors, semiconductors, and potentiometers: .... KIT 66-6 £8.38
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ADSR ENVELOPE SHAPER (Jan 1978):
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PCB for above: .... PCB 9725-1 £2.40

THREE LOW FREQUENCY OSCILLATORS (Mar 1978):
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NOISE GENERATOR (Mar 1978):
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For the full FORMANT assembly the following quantities are required: 3 of PCB 9721-4, 3 of KIT 66-4, 3 of PCB 9723-1, 2 of KIT 66-7, 2 of PCB 9725-1, and 1 of each of the other KITs and PCBs.

All FORMANT PCBs are as published in ELEKTOR

ELEKTOR PIANO (Sept 1978)
Details are in our list — Please send S.A.W.

DIGITAL REVERBERATION UNIT (May 1978)
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Set of resistors, capacitors, semiconductors, potentiometers, switches, and transformer: .... KIT 78-1 £48.12
PCB for above (redesigned): .... PCB 78A £2.86

EXTENSION UNIT:
Set of capacitors and semiconductors: .... KIT 78-2 £45.45
PCB for above (redesigned): .... PCB 78B £1.06

WAVEFORM CONVERTER (Oct/Nov 1977):
(Extracted from Formant for use as a separate unit)
Set of resistors, caps, semiconductors, potentiometers, and PCB .... KIT 67-1 £8.40

PHASING AND VIBRATO UNIT (Dec 1977):
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PCB for above (redesigned): PCB 70A £2.33

Photocopies of Elektor Texts for above projects are available.

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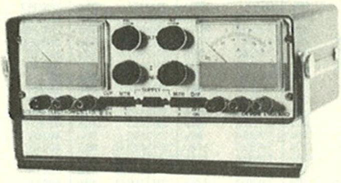

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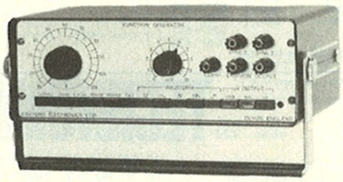

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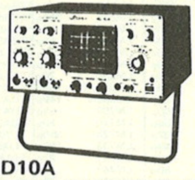

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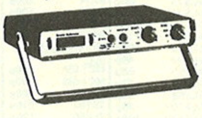

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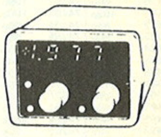

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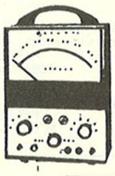
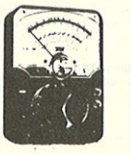
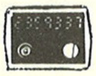


TM11



TMK500



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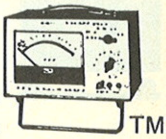

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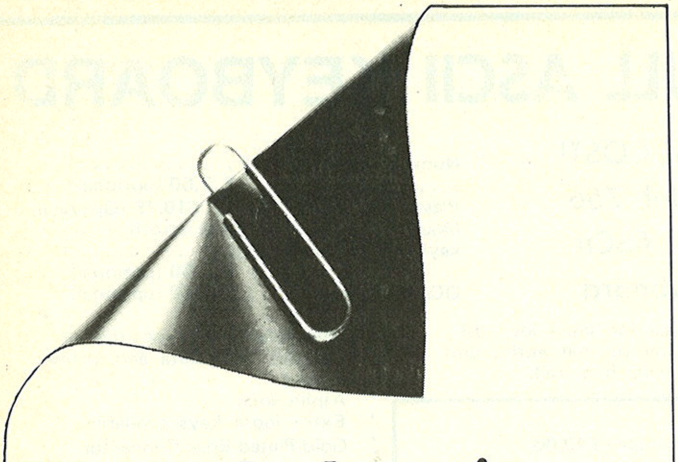

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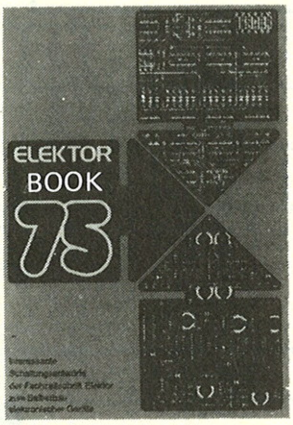

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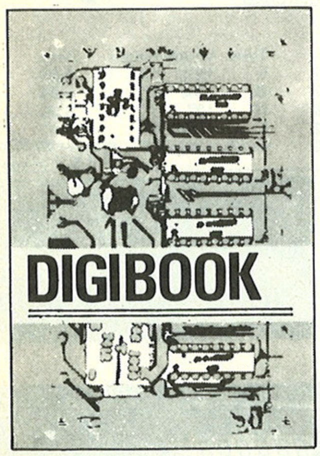

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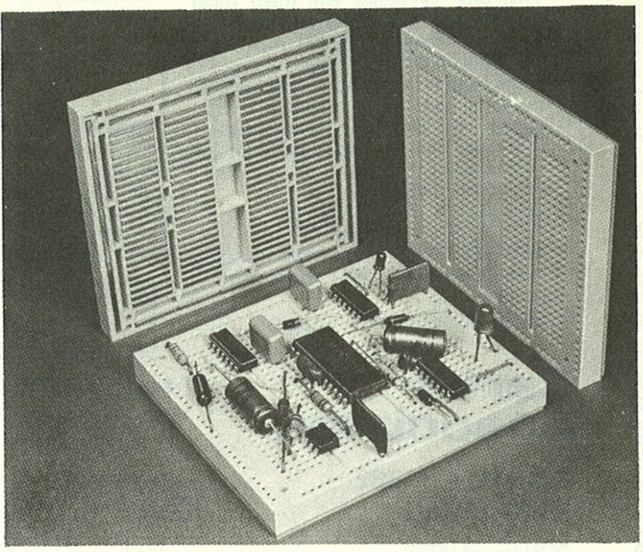

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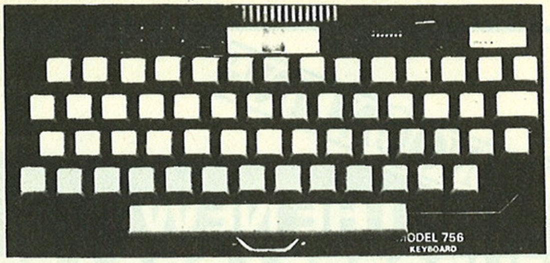

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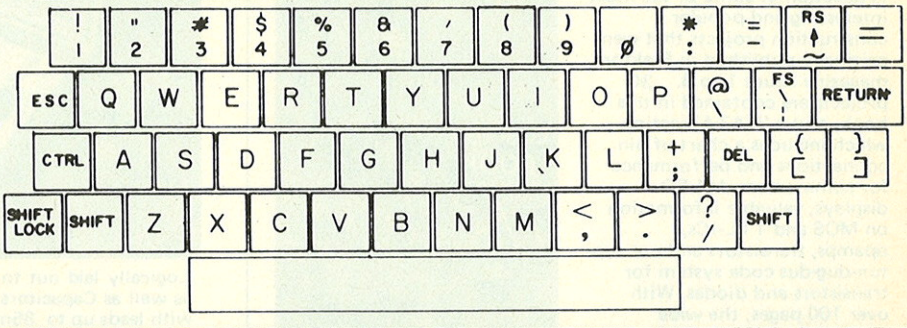

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4024	.54
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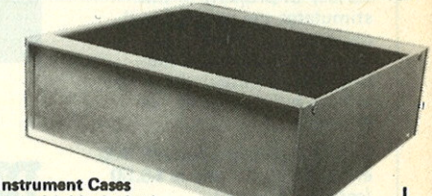

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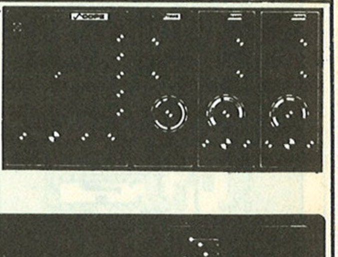

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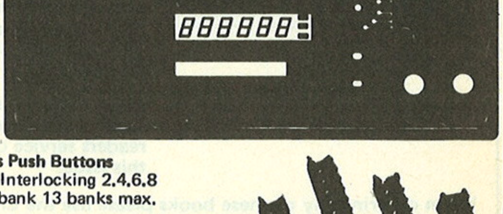

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2.2	06p	06p	06p	06p	06p	06p	12p	28p
3.3	06p	06p	06p	06p	06p	06p	12p	29p
4.7	06p	06p	06p	06p	06p	06p	12p	36p
10	06p	06p	06p	06p	06p	12p	13p	47p
22	06p	06p	06p	06p	12p	12p	20p	56p
33	06p	06p	06p	06p	12p	20p	22p	79p
47	06p	06p	06p	06p	16p	20p	28p	82p
100	08p	08p	08p	18p	19p	30p	36p	£1.45
220	12p	12p	12p	26p	38p	44p	50p	
330	17p	17p	17p	26p	49p	54p	£1.05	
470	13p	13p	18p	23p	46p	66p	£1.10	
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Please specify exact value and voltage required.
Remember larger voltage larger size.

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1					14p
2.2					14p
3.3					14p
4.7					14p
10		14p			15p
22	14p	14p			15p
33	14p	14p			15p
47	14p	14p			15p
100	14p	15p			26p
220	16p	17p			30p
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0.01		8p

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22/25V Axial	6p	50p	£ 4.00
100/16V Axial	8p	60p	£ 5.00
150/16V Axial	6p	50p	£ 4.00
200/50V Tag Ended	12p	£1.00	£ 9.00
1000/15V Axial	23p	£2.00	£18.00
1000/25V Axial	24p	£2.30	£22.00
741 Op Amp	22p	£1.95	£17.00
555 Timer	30p	£2.65	£24.00
Sliders 60mm 100K LOG	69p	£6.00	£50.00
Sliders 40mm 470K LIN/2M2 LOG	49p	£4.00	£30.00
10k LIN AB Pots Rotary	25p	£2.25	£20.00
100K LIN Tandem Pots	75p	£7.00	£65.00
1p 12w Lorlin Rotary Switch	39p	£3.80	£37.00
Polyester .01uF 250V	5p	40p	£ 3.00
,, .022uF 250V	5p	45p	£ 4.00
,, .33uF 250V	9p	80p	£ 7.00
TIL119 Darlington Opto Coupler	£1.65	£15.00	£130.00
3.5mm Jack Plugs	15p	£1.20	£10.00
¼" Switched Stereo Jack Sockets	29p	£2.70	£25.00
Cassette Plug Mains	19p	£1.70	£15.00
Cassette DC Switched Power IP Skt	19p	£1.70	£15.00
Dimmer Switches 500W	£1.99	£19.50	£190.00
Resister Packs 100Mix ¼ & ½W 100's	–	79p	–

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This Bi monthly Advertisement only shows some of our stock
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ALL PRICES INCLUDE VAT

RESISTORS

PRICE REDUCTIONS

CARBON FILM (Miniature)	
0.25W E24 series 10R – 1M 5%	
0.5W E24 series 10R – 10M 5%	
Sold in 10's of any one value	10p
Pack of E12 series 10 of each value (610 total)	£6.00
Pack of E24 series 10 of each value (1210 total)	£12.00
Expansion Pack E12 to E24 series (600 total)	£6.00
(PLEASE SPECIFY 0.25W OR 0.5W)	
1W E12 series 10R 10M 5%	5p each
2W E12 series 10R 10M 5%	9p each
METAL OXIDE	
0.5W E24 series 10R 1M 2%	4p each
WIRE WOUND	
2.5W E12 series 0.22R 270R	25p each
4W E6 series 1R 10K	25p each
7W E12 series 1R 22K	25p each
11W E6 series 1R 22K	25p each
17W E6 series 1R 22k	30p each
THERMISTORS	
Equiv. CZ4 650R to 37R Hot 0.3A	40p
Equiv. VA1026 or CZ13A 370R to 28R Hot 0.3A	40p
Equiv. VZ1104 or OD10 100R to 1R Hot 2.2A	40p
ROTARY POTENTIOMETERS (RS Type)	
Carbon track, ± 20%, insulated ¼" spindle	
LINEAR (0.5W) 5K 1M	38p each
LOG (0.25W) 5K 2M	38p each
DP Switched Lin 25K 500K	70p each
DP Switched Log 5K 1M	70p each
OPEN PRESETS (0.1W)	
E3 series 100R 4.7M Vert. or Horiz.	12p each
THICK FILM RESISTOR NETWORKS	
7 Individual Resistors in 14 pin DIL package Ideal for 7 segment LED displays 150R or 270R (state which)	72p each
13 Commoned Resistors in 14 pin DIL package suitable for Logic Pull Up/Down Resistors 1K; 4K7; 10K; 47K; 100K – all	72p each

SEMICONDUCTORS

RECTIFIER DIODES			
1N4001	50V	1A	4p
1N4002	100V	1A	5p
1N4003	200V	1A	6p
1N4004	400V	1A	7p
1N4005	600V	1A	8p
1N4006	800V	1A	9p
1N4007	1000V	1A	9p
1N5400	50V	3A	15p
1N5401	100V	3A	16p
1N5402	200V	3A	18p
1N5404	400V	3A	19p
1N5406	600V	3A	24p
1N5407	800V	3A	25p
1N5408	1000V	3A	29p
BY127	1250V	1.5A	12p

SIGNAL DIODES			
OA47	9p	OA202	8p
OA90	6p	1N914	5p
OA91	6p	1N4148	4p

ZENER DIODES		
400mW	1.3V to 39V	12p
1.3mW	1.3V to 100V	27p

LINEAR I.C.s	
CA3089E IF system	£1.79
CA3090AQ Stereo D	£3.99
LM324 Quad Op Amp	49p
LM380 2W Amp	£1.05
LM381 Stereo Preamp	£1.80
LM3900 Quad Amp	84p
MC1310 Stereo D	£1.49
MC1458	45p
531 Fast Slew Op Amp	£1.39
555 Timer	30p
556 Dual Timer	79p
566 VCO	£1.49
709 DIL Op Amp	24p
711 Comparator	38p
723 150mA Regulator	39p
741 Op Amp	22p
747 Dual 741 Op Amp	69p
748 Op Amp	35p
SN76013 Audio Amp	£1.39
SN76023 Audio Amp	£1.39
TBA800 5W Amp	69p

TRANSISTORS	
AD149	75p
BC107/8/9	12p
BC147/8/9	12p
BC157/8/9	12p
BC177/8/9	18p
BC182/3/4L	12p
BC212/3/4L	12p
BC477/8/9	19p
BC547/8/9	12p
BC557/8/9	15p
BC70/1/2	19p
BD139	39p
BD140	39p
BF184/5	29p
BF194/5/6	12p
BFY50/1	19p
BFY52/3	19p
BSX19/20	20p
MJE340	49p
TIP31/32A	49p

TIP41/42A	69p
TIS43	34p
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ZTX300/1/2	22p
ZTX303/4	22p
ZTX500/1	22p
ZTX502/3	22p
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MJ2955 PNP	99p
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2N3705/6/7/8	12p
2N3903/4	19p
2N3905/6	19p

MISC. THYRISTERS	
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C106D 3A 400V	49p
2N4443 5A 400V	89p

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MAINS (240V primary)

GENERAL PURPOSE		
6–0–6V	100mA	98p
9–0–9V	75mA	98p
12–0–12V	100mA	£1.13
0–6 0–6V	280mA	£2.00
0–12 0–12V	150mA	£2.00
0–4.5 0–4.5V	600mA	£2.48
0–6 0–6V	500mA	£2.48
0–12 0-12V	250mA	£2.48
0–15 0–15V	220mA	£2.48
0–20 0–20V	150mA	£2.48
0–6V	3.3A	£2.98
0–9V	2.2A	£2.98
0–12V	1.6A	£2.98
0–18V	1.1A	£2.98
0–24V	800mA	£2.98
6–0–6V	1½A	£3.80
9–0–9V	1A	£2.98
12–0–12V	1A	£3.60
15–0–15V	1A	£3.96
30–0–30V	1A	£4.99

GOOD REGULATION (Typically better than 10%)		
0–4.5 0–4.5V	600mA	£2.99
0–6 0–6V	500mA	£2.99
0–12 0–12V	250mA	£2.99
0–15 0–15V	200mA	£2.99
0–20 0–20V	150mA	£2.99
0–4.5 0–4.5V	2.2A	£3.75
0–6 0–6V	1.6A	£3.75
0–12 0–12V	800mA	£3.75
0–15 0–15V	600mA	£3.75
0–17.5 0–17.5V	500mA	£3.75
0–20 0–20V	500mA	£3.75
0–4.5 0–4.5V	5.5A	£5.31
0–6 0–6V	4.1A	£5.31
0–12 0–12V	2A	£5.31
0–15 0–15V	1.6A	£5.31
0–20 0–20V	1.2A	£5.31
0,19,25,33,40,50V	½A	£6.97
0,19,25,33,40,50V	1A	£7.96
0,19,25,33,40,50V	2A	£9.99

Prices include postage and packing

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What's coming in 1979?

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Please return your renewal as quickly as possible, we would hate you to miss a single copy. We list below the 1979 prices and we are sure you will agree its well worth the money to know you will receive your own copy every month through the post.

Our best regards for the future.

Elektor Subscription department.

1979 Subscription (including postage & packing) January no. 45 to December issue no. 56 £8.50 $21.00. (UK and overseas surface mail).
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IBM 1053 Printer similar to 735 but separate BCD o/p Keyboard. Will accept any IBM Golfball head. Motor is 220v 50 Hz. Print Solenoids are 50v. A parallel B.C.D. six bit code is required to print any character.

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RED 3mm/⅛"dia	9p*
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SET 5: Zeners 400 mW Total 100, 3 — 33 volt £5
SET 6: 100 presets £5

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Resistors ⅓ W 5% CF	2p
Presets Pr Vert	10p
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CAPACITORS Tants	12p
Ceramic 50v 5% HI STAB 22pf to 0.1uf .22 .47	5p
ELECTROLYTICS 25 volts	
1/10/47/100uf ALL	10p
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NEW PAK O: 12 x BC212 £1
PAK F: 13 x 2N3704 £1
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BC108	8p*	MJ2955	£1
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4008	65p*	7410	10p*
4009	35p*	7413	25p*
4010	15p*	7420	10p*
4011	14p*	7425	20p*
4013	35p*	7430	8p*
4015	60p*	7440	14p*
4016	35p*	7442	50p*
4017	55p*	7445	69p*
4018	65p*	7447	69p*
4020	60p*	7470	32p*
4023	15p*	7472	25p*
4024	45p*	7473	25p*
4025	15p*	7474	25p*
4027	35p*	7475	35p*
4028	52p*	7476	29p*
4029	60p*	7480	39p*
4030	35p*	7482	75p*
4042	54p*	7483	75p*
4043	55p*	7486	29p*
4046	100p*	7490	30p*
4049	28p*	7491	70p*
4050	28p*	7492	40p*
4066	40p*	7493	29p*
4067	400p*	7494	75p*
4070	16p*	7495	65p*
4073	16p*	7496	55p*
4081	16p*	74100	100p*
4082	21p*	74107	29p*
4510	70p*	74121	25p*
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74LS13	40p*	74LS162	130p*
74LS14	100p*	74LS163	120p*
74LS20	19p*	74LS164	120p*
74LS22	26p*	74LS165	75p*
74LS27	35p*	74LS173	100p*
74LS30	20p*	74LS174	100p*
74LS47	85p*	74LS175	100p*
74LS55	30p*	74LS181	300p*
74LS73	45p*	74LS190	95p*
74LS74	37p*	74LS191	95p*
74LS75	45p*	74LS192	130p*
74LS83	100p*	74LS193	130p*
74LS85	100p*	74LS195	130p*
74LS86	37p*	74LS196	110p*
74LS90	85p*	74LS221	95p*
74LS93	85p*	74LS240	230p*
74LS107	42p*	74LS241	230p*
74LS112	100p*	74LS242	230p*
74LS122	75p*	74LS243	230p*
74LS123	69p*	74LS245	300p*
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74LS132	100p*	74LS257	110p*
74LS133	55p*	74LS259	160p*
74LS138	55p*	74LS298	225p*
74LS139	55p*	74LS373	200p*
74LS151	100p*	74LS374	175p*

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All Lo Profile	
PCB DRILL ¼" chuck	£10*

TRIACS	
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BR100 Diac	25p
SCR 1A 400v	50p
C106D 4A 400v	50p
SWITCHES MINI	
DPDT	59p
SPST	55p
Push On	35p
Slide	25p

IC SUPERMARKET	
301 Op Amp	30p*
555 Timer (NE555)	27p*
556 Dual Timer	60p*
709 DIL 14	25p*
710 Comparator	40p*
723 Regulator	45p*
741C 8 pin DIL OPA	18p*
741 TO99 or DIL14	33p*
747 Dual 741	60p*
748C Op Amp	33p*
3900 Quad Op Amp	45p*
7805 1amp 5volt	60p*
7805 (TO3) LM309K	100p*
7808, 7812	60p*
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7900 Series	100p*
76013 & 76023	135p*
CA3130	85p*
CA3140	70p*
CA3046	49p
CA3054	100p
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LM381 Dual Preamp	105p
LM387 Dual Preamp	50p
LM3900 Quad OPA	45p*
MC1460, 61 & 69 A1	1300p*
MCMOS 14433 A/D	£10*
NE536 FET OPA	400p*
TBA810 7WAF	100p*
TL071 Lo Noise 741	75p*
TL081 FET 741	69p*
TL083 FET 747	149p*
TL080 FET 748/308	115p*
TL170 Hall Effect	69p*

WHO and WHERE

A directory of electronic component suppliers to Elektor readers

IF THERE IS A COMPONENT SHOP IN YOUR AREA NOT LISTED BELOW PLEASE LET US KNOW

AREA 1

ACE Mailtronix Ltd.,
Tootal Street, Wakefield,
W. Yorks. WF1 5JR.
Tel: 0924-250375

A. Marshall (London) Ltd
85 West Regent St.,
Glasgow G2 2QD
Tel: 041-332-4133

Aitken Bros. & Co.
35 High Bridge,
Newcastle upon Tyne,
NE1 1EW
Tel: 0632-26729

The Amateur Radio Shop
13, Chapel Hill,
Huddersfield, Yorkshire,
Tel. 20774

Bell's Television Services
190, Kings Road,
Harrogate, Yorkshire,
Tel. (0423) 55885

Derwent Radio
28 Hillcrest Avenue,
Scarborough, N. Yorkshire,
Tel: (0723) 63982

Electrovalue Ltd.
680 Burnage Lane,
Manchester M19 1NA
Tel: 061-432-4945

Gamma Enterprises
373 Blackness Road,
Dundee, DD2 1TL
Phone Dundee 643061

Greenbank Electronics
94 New Chester Road,
New Ferry, Wirral,
Merseyside L62 5AG,
Tel. 051-645 3391

S & M Turner
83 Rochdale Road,
Bury, Lancs,
Tel: 061 761 2069

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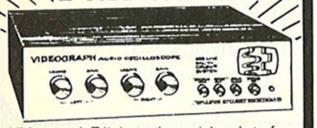

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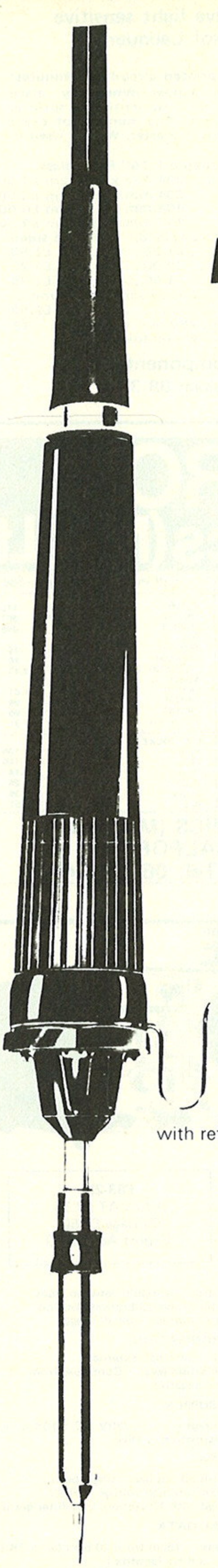

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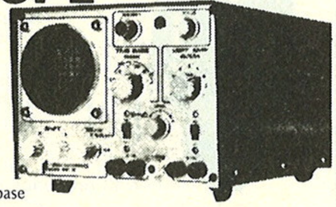

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AF124	0.25
AF125	0.28
AF126	0.25
AF127	0.25
AF139	0.19
AF178	0.29
AF179	0.29
AF180	0.29
AF181	0.29
AF186	0.29
AF239	0.29
ASY26	0.48
ASY27	0.29
ASY29	0.62
ASY73	0.29
ASZ17	0.59
AU107	1.00
AU113	0.90
AU210	0.90
BC107	0.06
BC107A	0.06
BC107B	0.06
BC108	0.06
BC108A	0.06
BC108B	0.06
BC109	0.06
BC113	0.10
BC114	0.10
BC115	0.10
BC116	0.11
BC116A	0.12
BC117	0.11
BC118	0.10
BC119	0.20
BC147	0.06
BC148	0.06
BC149	0.06
BC153	0.10
BC154	0.15
BC157	0.06
BC158	0.06
BC159	0.06
BC168	0.10
BC169	0.06
BC170	0.06
BC171	0.06
BC172	0.06
BC173	0.08
BC177	0.12
BC178	0.12
BC179	0.12
BC182L	0.09
BC183	0.09
BC183L	0.09
BC183LA	0.09
BC183LB	0.10
BC184	0.08
BC184L	0.09
BC186	0.19
BC187	0.19
BC204	0.08
BC204B	0.09
BC205	0.09
BC205A	0.10
BC206	0.10
BC206B	0.11
BC207	0.10
BC208	0.10
BC208B	0.11
BC208C	0.12
BC209	0.10
BC209B	0.11
BC212	0.10
BC212L	0.11
BC213	0.10
BC213L	0.10
BC214	0.10
BC214L	0.10
BC237	0.15
BC237A	0.16
BC237B	0.18
BC237C	0.21
BC238	0.15
BC238B	0.16
BC238C	0.18
BC239	0.21
BC251	0.10
BC251A	0.15
BC252B	0.17
BC252C	0.20
BC258	0.20
BC261	0.09
BC262	0.20
BC302	0.25
BC303	0.25
BC307	0.25
BC308	0.25
BC319C	0.25
BC327	0.09
BC327-16	0.10
BC328	0.09
BC337	0.09
BC338	0.09
BC347A	0.15
BC350A	0.17
BC441	0.20
BC461	0.24
BC537	0.29
BC547	0.10
BC547A	0.11
BC547B	0.11
BC547C	0.12
BC548A	0.11
BC548B	0.11
BC548C	0.11
BC557	0.09
BC557B	0.09
BC557C	0.10
BC558	0.09
BC559	0.09
BCX32	0.12
BCX36	0.12
BCY31	0.80
BCY40	0.50
BCY42	0.55
BCY58	0.20
BCY70	0.13
BCY71	0.13
BCY72	0.13
BCZ11	0.28
BD113	0.50
BD115	0.30
BD123	0.60
BD124	0.65
BD131	0.35
BD131/132	0.80
BD132	0.35
BD135	0.30
BD136	0.30
BD137	0.30
BD137/138	0.70
BD138	0.30
BD139	0.30
BD140	0.30
BD142	0.30
BD201	0.80
BD202	0.80
BD203	0.80
BD204	0.80
BD234	0.50
BD235	0.50
BD238	0.50
BD437	0.50
BDX77	0.90
BF153	0.08
BF178	0.20
BF179	0.20
BF180	0.15
BF181	0.15
BF182	0.15
BF183	0.15
BF184	0.15
BF185	0.15
BF194	0.06
BF195	0.06
BF196	0.06
BF197	0.06
BF200	0.25
BF202	0.30
BF203	0.30
BF324	0.20
BF336	0.25
BFS28	1.00
BFW10	0.40
BFW11	0.40
BFW30	1.00
BFW57	0.15
BFW58	0.15
BFX12	0.20
BFX29	0.20
BFX30	0.20
BFX84	0.27
BFX88	0.17
BFX89	0.17
BFY50	0.12
BFY51	0.12
BFY52	0.12
BFY90	0.50
BR101	0.26
BRY39	0.25
BRY56	0.25
BSV64	0.30
BSV79	0.75
BSV80	0.75
BSV81	0.85
BSX21	0.14
BSY40	0.27
BSY95A	0.12
BT106	0.96
BU105	1.50
BU126	0.80
BU204	1.50
BU205	1.60
BU207	1.80
OC22	1.40
OC29	0.85
OC44	0.12
OC45	0.12
OC71	0.09
OC72	0.12
OC75	0.10
OC81	0.12
OC82	0.48
TIP29A	0.40
TIP29B	0.45
TIP30	0.35
TIP30A	0.40
TIP30B	0.45
TIP31	0.35
TIP31A	0.40
TIP31B	0.45
TIP32	0.35
TIP32A	0.40
TIP32B	0.45
TIP41	0.35
TIP41A	0.40
TIP41B	0.45
TIP42	0.35
TIP42A	0.40
TIP42B	0.45
TIP2955	0.65
TIP3055	0.40
TIS90	0.18
2N393	0.30
2N404	0.29
2N456A	0.50
2N696	0.10
2N697	0.10
2N706	0.07
2N706A	0.08
2N708	0.08
2N918	0.36
2N929	0.14
2N987	0.12
2N1302	0.12
2N1303	0.15
2N1304	0.15
2N1307	0.20
2N1308	0.20
2N1309	0.20
2N1484	1.00
2N1507	0.15
2N1613	0.15
2N1671	1.10
2N1711	0.15
2N2218	0.15
2N2219A	0.18
2N2221	0.15
2N2222	0.15
2N2369	0.10
2N2401	0.30
2N2412	0.70
2N2483	0.22
2N2646	0.40
2N2904	0.15
2N2904A	0.15
2N2905	0.15
2N2905A	0.15
2N2906	0.12
2N2907A	0.12
2N2926G	0.08
2N29261	0.08
2N3053	0.12
2N3054	0.35
2N3055	0.35
2N3055 Motorola	0.50
2N3133	0.20
2N3442	1.00
2N3553	0.50
2N3702	0.08
2N3704	0.06
2N3705	0.06
2N3711	0.06
2N3715	1.89
2N3819	0.18
2N3903	0.10
2N3904	0.08
2N3905	0.08
2N3906	0.08
2N4058	0.10
2N4124	0.20
2N5036	0.30
2N5484	0.35

DIODES

AA119	0.17
AA121	0.11
AA129	0.08
AA143	0.15
AA144	0.09
BA102	0.30
BA111	0.98
BA115	0.25
BA145	0.15
BA148	0.12
BA154	0.10
BA155	0.12
BA156	0.12
BA157	0.45
BA158	0.65
BA159	0.75
BA182	0.45
BA201	0.15
BA243	0.85
BAX13	0.06
BAX16	0.07
BAX17	0.10
BB105B	0.35
BB105G	0.35
BB110G	0.45
BB142	1.25
BR100	0.20
BR101	0.30
BY100	0.20
BY103	0.35
BY118	1.45
BY126	0.15
BY127	0.10
BY130	0.15
BY133	0.10
BY134	0.45
BY142	0.45
BY164	0.50
BY176	3.45
BY179	0.90
BY182	1.85
BY184	0.70
BY187	1.30
BY198	0.75
BY199	0.55
BY201-2	0.40
BY201-3	0.40
BY201-4	0.45
BY201-5	0.55
BY201-6	0.55
BY203-12	0.60
BY203-16	0.65
BY203-20	1.00
BY204-4	0.45
BY204-8	0.65
BY204-10	0.75
BY206	0.30
BY210-400	0.45
BY210-600	0.50
BY210-800	0.55
BYX10	0.35
BYX55-350	0.45
BYX55-600	0.55
BYX71-350	0.90
BYX71-600	1.15
BZX61 series	0.18
BZY88 series	0.08
DK13	0.45
ITT44	0.10
ITT210	1.35
ITT827	2.35
ITT921	0.20
ITT923	0.35
ITT1075	0.25
ITT2001	0.25
ITT2002	0.20
MR502	0.75
MR813	0.90
MR854	1.80
MR856	2.10
MR992A	1.55
MV2203	1.60
MV5460	0.65
OA47	0.07
OA70	0.07
OA71	0.35
OA81	0.12
OA85	0.12
OA86	0.20
OA90	0.07
OA91	0.06
OA95	0.06
OA202	0.07
ST2	0.14
1N4001	0.04
1N4002	0.05
1N4003	0.05
1N4004	0.06
1N4005	0.06
1N4006	0.07
1N4007	0.08
1N4148	0.04
1N4150	0.45
1N4448	0.25
1N5401	0.12
1N5402	0.15
1N5403	0.15
1N5404	0.16
1N5405	0.25
1N5406	0.20
1N5407	0.19
1N5408	0.20
1N5450A	6.75
1N5761	0.60

LINEAR INTEGRATED CIRCUITS

CA3020	1.75
CA3046	0.80
CA3048	2.50
CA3065	1.58
CA3089E	7.88
CA3090Q	4.50
ETT6016	4.95
ETTR6016	4.95
MC1303L	1.50
MC1304P	2.00
MC1305	5.15
MC1307P	2.85
MC1310P	1.00
MC1327P	2.75
MC1327PQ	2.50
MC1330P	1.25
MC1339P	3.95
MC1349	3.35
MC1351P	1.25
MC1352P	1.45
MC1358PQ	3.85
SAA570	4.20
SAA700B	10.15
SAS560	2.75
SAS570	2.75
SBA750B	6.75
SC9503P	2.00
SC9504P	2.00
SL414A	4.85
SL415A	6.30
SL901B	8.50
SL917B	10.70
SL1310	5.65
SL1327	2.75
SL3046	2.60
SN76003N	2.50
SN76003ND	2.15
SN76013N	1.50
SN70613ND	2.15
SN76023N	1.50
SN76023ND	2.15
SN76033N	2.40
SN76110N	1.50
SN76131N	2.00
SN76226N	3.15
SN76226ND	3.15
SN76227N	2.50
SN76532N	3.15
SN76533N	2.70
SN76544N	1.80
SN76550N	1.80
SN76660N	0.80
SN76666N	1.60
TAA300	3.75
TAA310	3.15
TAA320	2.60
TAA350A	3.00
TAA435	3.40
TAA550	0.50
TAA550B	0.40
TAA570	2.85
TAA621	6.95
TAA630	8.55
TAA630S	5.10
TAA661A	1.70
TAA661B	1.80
TAA700	3.50
TAA840	4.50
TAD100	1.35
TBA120A	3.05
TBA120AS	1.50
TBA120S	2.70
TBA120SB	1.60
TBA120SQ	1.60
TBA281	4.70
TBA350A	3.00
TBA396	1.80
TBA440	3.60
TBA4406	3.95
TBA480Q	2.50
TBA400	2.25
TBA510	2.40
TBA510Q	2.50
TBA520	2.50
TBA520Q	2.50
TBA530	2.50
TBA530Q	2.50
TBA540	2.50
TBA540Q	2.25
TBA550	3.50
TBA550Q	3.80
TBA560	6.45
TBA560C	4.50
TBA560Q	7.35
TBA560CQ	3.00
TBA570	2.00
TBA570Q	2.00
TBA641A12	6.20
TBA641B11	5.65
TBA673	5.00
TBA700	3.95
TBA700Q	2.25
TBA720	5.10
TBA720A	5.10
TBA720AQ	2.10
TBA750	2.40
TBA750Q	2.50
TBA800	0.90
TBA800Q	2.85
TBA810A	3.40
TBA810S	1.10
TBA820	0.80
TBA915	7.35
TBA920	3.00
TBA920Q	3.50
TBA950-2	5.40
TBA950-2X	5.04
TBA990	4.95
TBA990Q	3.75
TCA160	5.10
TCA270	3.00
TCA270B	3.60
TCA270Q	3.60
TCA270S	2.25
TCA270SQ	3.40
TCA800	5.40
TCA800Q	12.40
TCA830	3.10
TDA440	6.75
TDA1327	2.85
TDA1327B	2.85
TDA1330	1.60
741	0.25

BRIDGE RECTIFIERS

CURRENT	VOLTAGE	ORDER CODE	PRICE
1A	50V	B1/50	0.25
1A	100V	B1/100	0.26
1A	200V	B1/200	0.28
1A	400V	B1/400	0.30
1A	800V	B1/800	0.34
2A	50V	B2/50	0.40
2A	100V	B2/100	0.45
2A	200V	B2/200	0.55
2A	400V	B2/400	0.65
2A	800V	B2/800	0.70
3A	200V	B3/200	0.70
3A	600V	B3/600	0.80
4A	100V	B4/100	0.90
4A	400V	B4/400	0.95
6A	50V	B6/50	0.95
6A	200V	B6/200	1.10
6A	400V	B6/400	1.20
10A	400V	B10/400	2.50
25A	50V	B25/50	4.00
25A	200V	B25/200	4.20
25A	400V	B25/400	4.30

I. C. SOCKETS

NO. OF PINS	ORDER CODE	PRICE
8	D8	0.10
14	D14	0.11
16	D16	0.13
20	D20	0.30
22	D22	0.35
24	D24	0.40
28	D28	0.45
40	D40	0.60

PANEL METERS

Size 2" x 2" x 1⅜"; requires 1¾ cut-out.

F.S.D.	ORDER CODE	PRICE
1mA	M1	5.50
500mA	M500	5.50

THYRISTORS

CURRENT	VOLTAGE	CASE	ORDER CODE	PRICE
80mA	30V	TO18	SO8/30	0.22
80mA	60V	TO18	SO8/60	0.24
80mA	200V	TO18	SO8/200	0.25
1A	50V	TO220	S1/50	0.25
1A	100V	TO220	S1/100	0.26
1A	200V	TO220	S1/200	0.28
1A	400V	TO220	S1/400	0.35
3A	50V	TO220	S3/50	0.25
3A	100V	TO220	S3/100	0.26
3A	200V	TO220	S3/200	0.30
3A	400V	TO220	S3/400	0.40
4A	50V	TO220	S4/50	0.36
4A	100V	TO220	S4/100	0.40
4A	200V	TO220	S4/200	0.50
4A	400V	TO220	S4/400	0.56
5A	400V	TO220	S5/400	0.56
7A	50V	TO220	S7/50	0.45
7A	100V	TO220	S7/100	0.50
7A	200V	TO220	S7/200	0.55
7A	400V	TO220	S7/400	0.60
8A	400V	TO220	S8/400	0.70

TRIACS

CURRENT	VOLTAGE	CASE	ORDER CODE	PRICE
3A	100V	TO220	T3/100	0.75
3A	200V	TO220	T3/200	0.80
3A	400V	TO220	T3/400	0.85
6A	200V	TO220	T6/200	1.00
6A	400V	TO220	T6/400	1.05
8A	400V	TO220	T8/400	1.35
10A	400V	TO220	T10/400	1.40
15A	400V	TO220	T15/400	2.00

ORDERING

Orders despatched by return of post. Payment with order, please add 20p for p/p with orders under £5, otherwise carriage free. No other charges – just send prices shown. Enquiries: please send s.a.e. Government departments and educational institutions just send official order. Mail order only.
Export orders welcome.

TTL

7400	.12
7401	.12
7402	.12
7403	.12
7404	.13
7405	.13
7406	.29
7407	.29
7408	.14
7409	.14
7410	.13
7411	.18
7412	.21
7413	.25
7414	.54
7416	.27
7417	.27
7420	.13
7421	.28
7423	.25
7425	.22
7426	.25
7427	.25
7428	.34
7430	.13
7432	.24
7433	.32
7437	.24
7438	.24
7440	.13
7441	.52
7442	.55
7444	.90
7445	.70
7446	.70
7447	.66
7448	.60
7450	.13
7451	.13
7452	.13
7454	.13
7460	.13
7470	.28
7472	.22
7473	.26
7474	.20
7475	.28
7476	.13
7483	.75
7484	.90
7485	.90
7486	.26
7489	2.00
7490	.35
7491	.65
7492	.45
7493	.36
7494	.80
7495	.55
7496	.62
7497	2.40
74100	.95
74105	.40
74107	.28
74109	.45
74110	.46
74111	.70
74116	1.60
74118	.82
74119	1.30
74120	.82
74121	.26
74122	.40
74123	.55
74125	.45
74126	.46
74128	.62
74132	.70
74141	.58
74142	2.02
74143	2.02
74144	2.02
74145	.65
74147	1.35
74148	1.20
74150	1.00
74151	.60
74153	.60
74154	1.06
74155	.63
74156	.63
74157	.63
74158	1.70
74160	.80
74161	.80
74163	.80
74164	.90
74165	.90
74166	1.00
74167	2.70
74170	1.70
74172	4.00
74173	1.20
74174	.90
74175	.70
74176	.90
74177	.90
74178	1.20
74179	1.10
74180	.70
74181	1.95
74182	.75
74184	1.20
74185	1.20
74186	7.20
74188	5.40
74190	1.10
74191	1.00
74192	1.00
74193	1.10
74194	.92
74195	.85
74196	.92
74197	.92
74198	1.60
74199	1.50

CMOS

4000	.15
4001	.15
4002	.20
4006	.95
4007	.20
4008	.94
4009	.46
4010	.50
4011	.15
4012	.15
4013	.35
4014	.85
4015	.80
4016	.45
4017	.55
4018	.90
4019	.45
4020	.60
4021	.85
4022	.85
4023	.20
4024	.68
4025	.20
4026	1.35
4027	.35
4028	.70
4029	.90
4030	.50
4033	1.40
4035	1.10
4040	.90
4041	.80
4042	.75
4043	.85
4044	.85
4049	.28
4050	.45
4051	.88
4052	.88
4053	.88
4055	1.00
4060	1.00
4066	.35
4068	.20
4069	.20
4070	.20
4072	.20
4073	.20
4075	.20
4076	1.10
4078	.20
4081	.20
4082	.20
4502	.90
4507	.52
4508	2.30
4510	1.10
4511	.70
4512	.95
4516	.70
4518	.65
4520	1.10

RESISTORS

¼W Values available in E12 series from 10R to 1M. **Price 0.03 each.**
½W Values available in E 12 series from 1R0 to 10M. **Price 0.03 each.**
1W Values available in E12 series from 2R2 to 10M. **Price 0.06 each.**
2W Values available in E12 series from 10R to 10M. **Price 0.11 each.**
5W Values available in E6 series from 1R0 to 6K8.
Prices 1R0 to 1K0 **0.19 each.**
1K5 to 3K3 **0.22 each.**
4K7 to 6K8 **0.24 each.**
7W Values available in E12 series from R47 to 22K.
Prices R47 to R82 **0.25 each.**
1R0 to 1K0 **0.26 each.**
1K2 to 12K **0.27 each.**
15K to 22K **0.28 each.**
11W Values available in E6 series from 1R0 to 22K.
Prices 1R0 to 1K0 **0.29 each.**
1K5 to 12K **0.30 each.**
15K to 22K **0.35 each.**
17W Values available in E6 series from 1R0 to 22K.
Prices 1R0 to 4K7 **0.39 each.**
6K8 to 22K **0.41 each.**

½W Single turn cermet potentiometer. Values available 100R, 200R, 500R, 1K0, 2K0, 5K0, 10K, 20K, 50K, 100K, 200K, 500K, 1M.
Price 0.97 each.

¾W Multiturn cermet potentiometer. Values available 20R, 50R, 100R, 200R, 500R, 1K0 2K0, 5K0, 10K, 20K, 100K, 500K.
Price 1.40 each.

1W Potentiometer with 2" spindle. Values available 10R, 25R, 50R, 100R, 250R, 500R, 1K0, 2K5, 5K0, 10K, 20K.
Prices 10R to 5K0 **1.51 each.**
10K & 20K **1.62 each.**

1.5W Convergence preset potentiometer. Values available 5R0, 7R0, 10R, 15R, 20R, 100R, 500R.
Price 0.50 each.

2W 10 Turn potentiometer. Values available 100R, 200R, 500R, 1K0, 2K0, 5K0, 10K, 20K, 50K, 100K.
Price 7.34 each.

CAPACITORS

Tantalum Bead

6.3V	47uF	0.32 each
	100uF	0.50 each
16V	10uF	0.24 each
	22uF	0.30 each
	47uF	0.50 each
25V	22uF	0.41 each
35V	0.1uF	0.22 each
	0.22uF	0.22 each
	0.47uF	0.22 each
	1.0uF	0.22 each
	2.2uF	0.22 each
	4.7uF	0.24 each

Disc Ceramic

8kV	150pF	0.27 each
	180pF	0.27 each
	200pF	0.27 each
	220pF	0.27 each
	250pF	0.40 each
	270pF	0.40 each
	300pF	0.40 each

Mixed Dielectric

600V	1uF	1.01 each
1kV	0.01uF	0.26 each
	0.033uF	0.32 each
	0.047uF	0.35 each
	0.1uF	0.39 each
	0.22uF	0.58 each
	0.47uF	0.89 each
1.25kV	0.1uF	0.50 each
1.5kV	0.001uF	0.24 each
	0.0022uF	0.24 each
	0.0047uF	0.24 each
	0.22uF	0.28 each

Single Ended Electrolytic

16V	10uF	0.11 each
	22uF	0.11 each
	47uF	0.11 each
	100uF	0.11 each
	220uF	0.14 each
	470uF	0.28 each
	1000uF	0.32 each
63V	1uF	0.11 each
	2.2uF	0.11 each
	4.7uF	0.11 each
	10uF	0.13 each
	22uF	0.16 each
	47uF	0.22 each
	100uF	0.32 each
	220uF	0.46 each

Double Ended Electrolytic

10V	22uF	0.14 each
	100uF	0.14 each
	220uF	0.17 each
	470uF	0.36 each
	1000uF	0.40 each

25V	10uF	0.14 each
	22uF	0.14 each
	47uF	0.17 each
	100uF	0.17 each
	220uF	0.36 each
	470uF	0.47 each
	1000uF	0.72 each
63V	1uF	0.14 each
	2.2uF	0.14 each
	4.7uF	0.14 each
	10uF	0.17 each
	22uF	0.17 each
	47uF	0.29 each
	100uF	0.40 each
	220uF	0.65 each
	470uF	0.66 each
	1000uF	1.01 each
	2200uF	1.44 each
100V	10uF	0.20 each
	22uF	0.25 each
	47uF	0.36 each
	100uF	0.61 each
	220uF	0.68 each
450V	1uF	0.27 each
	4.7uF	0.45 each
	10uF	0.53 each
	22uF	1.07 each
	33uF	1.22 each

Silvered Mica

500V	3.3pF	0.18 each
	5pF	0.18 each
	10pF	0.18 each
	39pF	0.18 each
	100pF	0.18 each
	150pF	0.18 each
	180pF	0.18 each
	220pF	0.18 each
	330pF	0.36 each
	470pF	0.36 each
	680pF	0.36 each
	820pF	0.36 each
	1000pF	0.42 each
	2200pF	0.50 each
	8200pF	1.58 each
	10000pF	1.62 each

Multi-sectional Electrolytic

30V	2500/2500uF	1.94 each
70V	2500/2500uF	2.70 each
300V	150/150/100uF	2.81 each
350V	200/300uF	2.46 each
	200/200/100/32uF	3.89 each
	150/100/100/100/150uF	4.75 each
	400/400uF	4.75 each
	300/300/150/100/50uF	5.18 each

NORMAN INSKIP

90, Charles Street,
Greenhithe, Kent.
Tel: Greenhithe (0322) 844985

TTL ★

7400	10p	74109	25p
7401	10p	74118	75p
7402	10p	74120	80p
7403	10p	74121	25p
7404	12p	74122	35p
7405	12p	74123	40p
7406	25p	74125	35p
7407	25p	74126	35p
7408	12p	74128	60p
7409	12p	74130	120p
7410	12p	74131	90p
7411	15p	74132	45p
7412	15p	74135	90p
7413	25p	74136	80p
7414	45p	74137	90p
7416	25p	74138	100p
7417	25p	74141	50p
7420	12p	74142	180p
7421	20p	74143	270p
7422	15p	74144	270p
7423	20p	74145	55p
7425	20p	74147	100p
7426	22p	74148	90p
7427	22p	74150	65p
7428	25p	74151	45p
7430	12p	74153	45p
7432	20p	74154	70p
7433	28p	74155	45p
7437	20p	74156	45p
7438	20p	74157	45p
7440	12p	74160	55p
7441	45p	74161	55p
7442	40p	74162	55p
7443	60p	74163	55p
7444	60p	74164	60p
7445	65p	74165	60p
7446	50p	74166	75p
7447	50p	74167	160p
7448	50p	74170	100p
7450	12p	74173	80p
7451	12p	74174	60p
7453	12p	74175	60p
7454	12p	74176	50p
7460	12p	74177	50p
7470	25p	74178	75p
7472	20p	74179	120p
7473	25p	74180	90p
7474	25p	74181	130p
7475	25p	74182	50p
7476	25p	74184	120p
7480	40p	74185	100p
7481	85p	74188	320p
7482	75p	74190	70p
7483	75p	74191	70p
7484	70p	74192	60p
7485	60p	74193	60p
7486	25p	74194	55p
7489	130p	74195	50p
7490	25p	74196	50p
7491	40p	74197	50p
7492	35p	74198	100p
7493	30p	74199	100p
7494	70p	74293	90p
7495	45p	744500	18p
7496	45p	745112	80p
7497	120p		
74100	80p		
74104	40p		
74105	40p		
74107	25p		
74108	100p		
74166	75p		

7805	140p
7812	140p
7815	140p
7818	140p
7824	150p

CMOS

4000	12p	4040	60p
4001	12p	4043	60p
4002	12p	4046	90p
4006	80p	4047	80p
4007	14p	4048	50p
4009	30p	4049	25p
4011	12p	4050	25p
4012	12p	4054	100p
4013	30p	4055	130p
4015	50p	4056	120p
4016	30p	4060	100p
4017	50p	4066	35p
4018	55p	4069	12p
4019	40p	4070	12p
4020	50p	4071	12p
4022	50p	4072	12p
4023	12p	4081	12p
4024	40p	4082	12p
4025	12p	4093	70p
4026	80p	4516	60p
4027	30p	4510	70p
4028	45p	4516	65p
4029	50p	4518	65p
4030	30p	4520	65p
4032	80p	4528	80p
4033	100p	4583	70p

POWER SUPPLY CAPS

2200/16	35p		
2200/40	50p	4700/63	120p
2200/63	80p	4700/70	135p
2200/100	150p	10000/10	100p
3300/30	50p	10000/25	150p
3300/63	90p	15000/15	150p
4700/40	65p	22000/25	200p
4700/25	50p		

ENQUIRES FOR ANY OTHER TYPES

TRANSISTORS

AA113	10p	BC172	12p	BDX32	200p	BY127	15p
AA217	30p	BC177	15p	BDX42	50p	BY164	50p
AC121	30p	BC178	15p	BDY10	100p	BY133	25p
AC126	20p	BC182	10p	BF115	20p	BY164	50p
AC127	20p	BC182L	12p	BF120	50p	BYX94	8p
AC127/01	25p	BC183	10p	BF121	45p	C1120	30p
AC128	20p	BC183L	12p	BF123	45p	C1164	20p
AC151	25p	BC184	10p	BF125	45p	F100	42p
AC153	30p	BC184L	12p	BF127	50p		
AC153K	40p	BC186	20p	BF137	35p		
AC154	30p	BC204	12p	BF154	18p	E300	47p
AC187	20p	BC205	12p	BF160	18p	E310	60p
AC188	20p	BC207	12p	BF161	18p	E420	180p
ACY17	35p	BC212	11p	BF173	20p	E430	12p
ACY19	35p	BC212L	12p	BF178	25p	MJE340	45p
ACY20	35p	BC213	12p	BF179	25p	MPSA05	30p
ACY22	40p	BC213L	15p	BF180	30p	MPSA06	32p
ACY40	50p	BC214	15p	BF181	30p	MPSA56	32p
ACY41	50p	BC214L	18o	BF182	30p	TIP29	34p
ACY42	50p	BC237	10p	BF183	25p	TIP29A	40p
AD130	150p	BC237B	15p	BF184	20p	TIP29C	40p
AD143	150p	BC268	16p	BF186	25p	TIP30	35p
AD149	80p	BC294	30p	BF194	10p	TIP30A	40p
AD161	30p	BC300	25p	BF195	10p	TIP30B	40p
AD162	30p	BC301	25p	BF196	10p	TIP30C	45p
AD161 2MP	70p	BC303	30p	BF197	10p	TIP31	40p
AF114	25p	BC307	15p	BF198	25p	TIP31A	45p
AF115	25p	BC308	15p	BF199	25p	TIP31B	50p
AF116	25p	BC317	12p	BF200	30p	TIP31C	55p
AF117	25p	BC318	12p	BF224	20p	TIP32	40p
AF118	80p	BC323	30p	BF225	20p	TIP33	60p
AF178	95p	BC328	18p	BF241	16p	TIP34	70p
AF139	35p	BC337	20p	BF244B	35p	TIP35	200p
AF239	45p	BC338	18p	BF255	25p	TIP35C	225p
AF279	50p	BC348	20p	BF257	25p	TIP41A	70p
AU110	180p	BC461	35p	BF258	25p	TIP41B	75p
BA114	12p	BC516	35p	BF259	25p	TIP41C	80p
BA121	12p	BC517	35p	BF271	25p	TIP42A	80p
BA154	12p	BC547	12p	BF274	30p	TIP42B	85p
BA157	15p	BC547B	13p	BF324	30p	TIP42C	90p
BA173	15p	BC548	12p	BF336	35p	TIP2955	70p
BAX13	5p	BC548C	14p	BF337	35p	TIP3055	50p
BAX16	5p	BC549B	13p	BF367	20p	TIS90	25p
BAW21	20p	BC549C	14p	BF394	35p	TIS91	25p
BB105	35p	BC557	13p	BF458	50p	IN914	5p
BA110	35o	BC557B	15p	BF594	50p	IN3754	20p
BC107	10p	BCY34	80p	BF596	50p	IN4001	5p
BC108	10p	BCY38	100p	BF597	50p	IN4002	5p
BC108C	15p	BCY42	25p	BFR40	30p	IN4003	5p
BC109	10p	BCY43	25p	BFR80	30p	IN4004	5p
BC109C	15p	BCY58	18p	BFW58	20p	IN4005	5p
BC113	12p	BCY59	25p	BFW60	25p	IN4006	6p
BC114	15p	BCY70	15p	BFW88	30p	IN4007	7p
BC115	15p	BCY71	20p	BFW89	30p	IN4148	4p
BC116	15p	BCY72	15p	BFW91	30p	2N456A	90p
BC117	18p	BD115	45p	BFX29	25p	2N929	20p
BC118	12p	BD121	85p	BFX34	25p	2N930	20p
BC119	25p	BD131	35p	BFX38	25p	2N1302	25p
BC125	16p	BD132	35p	BFX44	35p	2N1303	30p
BC125B	20p	BD133	45p	BFX48	45p	2N1305	30p
BC126	20p	BD135	35p	BFX81	100p	2N1306	38p
BC134	15p	BD136	35p	BFX85	30p	2N1308	50p
BC136	16p	BD137	40p	BFX87	25p	2N1711	22p
BC137	16p	BD139	40p	BFX88	25p	2N2219A	25p
BC138	30p	BD140	40p	BFY10	30p	2N2483	30p
BC140	30p	BD144	160p	BFY18	100p	2N2906	16p
BC141	30p	BD181	100p	BFY19	100p	2N2907	20p
BC142	30p	BD182	100p	BFY50	20p	2N3053	20p
BC143	30p	BD188	130p	BFY51	20p	2N3054	50p
BC147	10p	BD207	70p	BFY52	20p	2N3055	60p
BC148	10p	BD220	65p	BFY53	25p	2N3702	11p
BC148C	14p	BD222	65p	BFY90	75p	2N3703	12p
BC149	10p	BD233	50p	BR101	35p	2N3704	12p
BC153	16p	BD238	50p	BRY39	35p	2N3705	12p
BC154	18p	BD242	60p	BRY56	35p	2N3706	12p
BC157	10p	BD252	50p	BSX20	20p	2N3708	12p
BC158	10p	BD263	65p	BSY40	25p	2N3715	300p
BC159	10p	BD607	80p	BSY95	20p	2N3819	25p
BC167A	12p	BD608	80p	BT100A	80p	2N3866	95p
BC168	14p	BD609	80p	BU105	200p	2N3904	15p
BC169	15p	BD610	80p	BU133	180p	2N6027	50p
BC171	12p	BD679	75p	BU208	220p	2SD234	50p
		BD680	75p	BY100	25p	2N5777	60p
				BY126	15p		

MURATA ULTRASONIC TRANSDUCERS 40k Hz

Type	MA40	LIS	Transmit
Type	MA40	LIR	Receive

£2.00 each **£3.50** pair
Data 10p

ROTARY SWITCHES BY LORLIN

1 POLE 12 WAY 2 POLE 6 WAY 3 POLE 4 WAY 4 POLE 3 WAY **All at 40p Each.**

OPTO ELECTRONIC CORNER

SPECIAL SCOOP OFFER
0.125 or 0.2 inch RED LEDS **15p each.** 10 for **£1.00,** 100 for **£7.50,** 1000 for **£60.00.**
0.125 or 0.2" Yellow and Green LEDS **15p,** 10 for **£1.40,** 100 for **£12.00.**

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FND500 Seven Segment Common Cathode Displays. Character Height 0.5" **£1.30 each.** 4 for **£5.00.**
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ORP12 Japanese **75p each.**
Mullard **£1.25 each.**

DECODER BOARD CONTAINING

18 x 74156. 2 x 74155 2 x 7409
1 x 74180 1 x 74150 1 x TIP32
2 x 60 WAY EDGE CONNECTORS
Few only left of this unreap unrepeatable bargain **£3.50 each.**

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XTAL MIC Inserts **75p each.**
5" Scopetubes SE5J (for callers only) **£15.00 each.**
Bias Rejector coils 50– 100KHZ **65p each**

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1 MHz CRYSTALS **£3.00**
Push to Make Switches **20p each.**
Chokes 10uH **35p each**
100uH **65p each**

Futaba 5LT02 Non-Multiplexed 4 Digit Phosphor Diode Display With A.M./P.M./Colon **£5.00**

LINEAR

AY38500	450p	NE556	90p
CA3039	70p	NE562B	400p
CA3046	60p	SAD1024	150p
CA3060	225p	SL917B	650p
CA3065	200p	SN76003N	150p
CA3076	250p	SN76013N	110p
CA3080	75p	SN76013ND	125p
CA3084	250p	SN76023N	110p
CA3085	85p	SN76023ND	125p
CA3086	60p	SN76033N	150p
CA3088	190p	SN76227N	160p
CA3089	160p	SN76228N	180p
CA3090AQ	360p	SN7666DN	76p
CA3123E	130p	TAA300	100p
CA3130	100p	TAA350	190p
CA3140	60p	TAA550	35p
LF356	80p	TAA570	220p
LF357	80p	TAA661B	140p
LM211H	250p	TAA700	350p
LM3002R5	170p	TAA790	350p
LM301AN	30p	TAD100	150p
LM304	200p	TAD110	130p
LM307N	65p	TBA1205	60p
LM308TO5	100p	TBA120T	85p
LM308DIL	100p	TBA480Q	200p
LM309A	100p	TBA520Q	200p
LM310TO5	150p	TBA530Q	200p
LM311TO5	150p	TBA540	200p
LM317K	325p	TBA550Q	250p
LM324	70p	TBA560C	250p
LM339	60p	TBA641A12	250p
LM348N	90p	TBA700	180p
LM380	60p	TBA720Q	225p
LM381N	90p	TBA750Q	200p
LM382	90p	TBA800	80p
LM391	180p	TBA810	100p
LM555	25p	TBA820	100p
LM709C	40p	TBA920Q	280p
LM710TO5	60p	TCA270Q	220p
LM710DIL	65p	TCA270S	220p
LM723TO5	40p	TCA760	300p
LM723DIL	40p	TCA4500A	450p
LM733	120p	TDA1008	350p
LM741	20p	TDA1034	450p
LM748	40p	TDA2002	300p
LM1303N	100p	TDA2020	300p
LM1458	100p	TL084	120p
LM3080	75p	XR320	250p
LM3900	55p	XR2206	450p
LM3909N	65p	XR2207	450p
MC1310P	140p	XR2208	600p
MC1312P	150p	XR2216	650p
MC1314P	190p	XR2567	250p
MC1315P	230p	XR4136	150p
MK50398	650p	XR4202	150p
MM5314	380p	XR4212	150p
MM5316	480p	XR4739	150p
NE529K	150p	ZN414	100p
NE555	25p	95H90	700p

ELEC CAPACITORS

0.47/25	7p	47/10	8p
1/16	7p	47/16	8p
1/25	7p	47/25	8p
1/50	7p	47/35	8p
2.2/25	7p	47/50	9p
2.2/35	7p	100/10	8p
3.3/25	7p	100/16	8p
4.7/10	7p	100/25	8p
4.7/16	7p	100/50	8p
4.7/25	7p	100/63	16p
4.7/50	7p	220/16	12p
6.8/25	7p	220/25	14p
10/10	7p	220/50	22p
10/16	7p	330/25	17p
10/25	7p	330/35	18p
10/50	7p	330/50	20p
22/6V3	7p	470/10	14p
22/10	7p	470/25	19p
22/16	7p	470/35	20p
22/25	7p	470/50	24p
22/35	7p	1000/16	27p
22/50	8p	1000/25	30p
33/6V3	7p	1000/35	35p
33/16	8p	1000/40	40p
33/25	8p	1000/63	50p
33/40	8p	1200/63	60p
33/50	9p	2200/10	30p

POLY CAPS

1000 PF	5p	0.1 uF	6p
2200	5p	0.22 uF	7p
3300	5p	0.33 uF	9p
4700	5p	0.47 uF	12p
6800	5p	1.0 uF	20p
0.01 uF	5p	2.2 uF	25p
0.022 uF	5p	4.7 uF	35p
0.033 uF	5p	6.8 uF	40p
0.047 uF	5p	10 uF	60p

TANT. BEADS

0.1/35V	14p	3.3/16V	14p
0.15/35V	14p	4.7/16V	14p
0.22/35V	14p	4.7/25V	14p
0.33/35V	14p	4.7/35V	14p
0.47/10V	14p	6.8/6V3	14p
0.47/35V	14p	6.8/35V	14p
0.68/35V	14p	1.0/35V	14p
1.00/10V	14p	22/15V	21p
1.00/35V	14p	33/16	25p
1.5/35V	14p	47/3V	20p
2.2/25V	14p	47/16V	25p
2.2/35V	14p	100/3V	25p

SPECIAL OFFERS

100 off 741	1500p
100 off 555's	1900p
100 off IN4148	150p
100 off AD161	2500p
100 off AD162	2500p
100 off .185 Red Leds	750p
100 off .2 Red Leds	750p
100 off Green/Yellow Leds	1200p

ASSORTED GIANT SCREW PACKS
INCLUDES
SELF TAPPING, SELF CUTTING
NUTS, BOLTS, WASHERS,
EYELETS ETC. ETC.
WEIGHT 1kg 2.2lbs.
Approx 1400 items
ONLY **£1.80** (U.K. only)

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1N4148
DIODES BY ITT/TEXAS 100 for **£1.50**. Please note, these are full **spec** devices.

Texas TIS 88A V.H.F. F.E.T. 10 for **£2.30**
100 for **£20.00**

555 TIMER
10 for **£2.50**

741 O.P. Amp ★
10 for **£2.00**

MULLARD MODULES

LP1152	100p
LP1153	400p
LP1165	400p
LP1166	400p
LP1168	400p
LP1169	400p
LP1173	400p
LP1181	400p
LP1400	400p
EP9000	280p
EP9001	280p
EP9002	280p
ELC1043/05	450p

POTENTIOMETERS

1K LIN	5K LOG
5K LIN	10K LOG
10K LIN	25K LOG
25K LIN	50K LOG
50K LIN	100K LOG
100K LIN	250K LOG
250K LIN	500K LOG
500K LIN	1M LOG
1M LIN	2M LOG
2M LIN	**All at 30p Each**

GANGED POTS
All at 80p Each.
5K + 5K LIN or LOG
10K + 10K LIN or LOG
25K + 25K LIN or LOG
50K + 50K LIN or LOG
100K + 100K LIN or LOG
250K + 250K LIN or LOG
500K + 500K LIN or LOG
1M + 1M LIN or LOG
2M + 2M LIN or LOG

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LIMITED OFFER
BC237
100 for
£5,00
★ ★

ELEKTORNADO AMPLIFIER KIT.
All parts **£12.00**
P.C. Board **£2.95**
Power Supply parts **P.O.A.**

DIL SOCKETS

8 PIN	13p
14 PIN	14p
16 PIN	15p
28 pin	45p

¼ GHz COUNTER

Time base and control board parts	£22.44
P.C. Board extra	£7.85
Counter and Display board parts	£31.76
P.C. Board extra	£8.95
L.F. Input board parts	£4.01
P.C. Board extra	£1.40
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A.. P.C. Boards extra	£19.50
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